Story Beads: *a wearable for distributed and mobile storytelling*

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Abstract

Stories take hundreds of different forms and serve many functions. They can be as energetic as an entire life story or as simple as a case of directions to a favorite beach. Storytelling processes are challenged and changed by technological developments in the worlds of text and image manipulation. The invention of writing changed the story from an orally recounted form which was mediated by the storyteller, to a recorded exact version, instead of a fleeting experience, a spoken weaving of a storyteller's tale. The story became an immutable object. In cinema stories are told with a sequence of juxtaposed still images moving at a speed fast enough to fool the eye into seeing a continuously changing image instead of one image after another. Television eventually coerced storytelling into 30-minute segments linked together, week by week, over a season broadcast to a large audience. The invention of the computer allowed storytelling to become flexible within a smaller granularity of content. Using the computer capabilities for storage and manipulation of information, authors can design stories and present them to different viewing audiences in different ways. Mobile computing, like the technological developments that came before it, will demand its own storytelling processes and story forms.

This thesis defines a specific storytelling process, which I call *Transactional Storytelling.* Transactional Storytelling is the construction of story through trade and repurposing of images and image sequences.

StoryBeads are wearable computers developed as a tool for constructing image-based stories by allowing users to sequence and trade story pieces of image and text. *StoryBeads* are modular, wearable computer necklaces made of tiny computer "beads" capable of storing or displaying images. Beads communicate by infrared light, allowing the trade of digital images by beaming from bead to bead or by trade of a physical bead containing images.

My thesis proposes a tool for mobile story creation that will produce a unique storytelling process for constructing image-based stories.

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Dedication

To my mom, Dorothy.

Acknowledgements

This work was written while sitting down, my fingers, eyes and mind the only things moving. It has been a roller coaster ride. The slow nervous climbs to the pinnacles of thinking, screaming down slopes of editing and clinging to the hairpin turns of ideas. Exiting this ride, I am changed. There are reasons why roller coaster cars are built with pairs of seats instead of single ones. The ride should not be endured or enjoyed alone. During the last two years of research, manifesting in this thesis, teachers, family, colleagues and friends have ridden next to me, people without whom I would have hesitated in the ticket line, been flung from the car or simply fainted mid-ride, missing the great view.

Being a researcher in the Interactive Cinema group at the MIT Media Lab has broadened my artistic life in ways I could never have imagined. Glorianna Davenport, my advisor, has made it possible through her unwavering support. I am humbled by her ability to run an idea to the sky and focus it with the precision. She expanded my world to include the beauty of Antonioni, the maze of Bruner and the possibilities of Schank.

To my readers, Mitchel Resnick and Brian Smith, I am grateful not only for their insightful contributions to this document, but their strength as teachers. Their classes helped shape the ideas for this work. Thank you.

My colleagues and friends in Interactive Cinema, past and present, have challenged, ignited and strengthened my convictions about storytelling and interactivity. My thanks to Freedom Baird, Arjan Schutte, Flavia Sparacino, Phillip Tiongson, Brian Bradley, Paul Nemirovsky, Pengkai Pan, Roger Sipitakiat, James Seo and Aisling Kelliher. Two students in Interactive Cinema have profoundly influenced my life and work. Kevin Brooks, my friend and storytelling mentor, has taught me the power of a tale, whether roller coasters or trains, and the good sense to look at research possibilities through the lens of story. Tara Rosenberger Shankar, my friend and esteemed work ally, has inspired me to work with rigor and sanity and been witness to the nervous loops, brick walls and energetic victories of the past year. I think, Tara, was there for most, if not all, of the hairpin turns.

The MIT undergraduates (UROPs) who worked on this project had incredible perseverance, creativity and the sheer ability to write miles of code, finding the tiny nagging bugs, and extracting them, allowing the beads to talk, store and move. The Story Bead team, in order of appearance: George Lee, Eric Gunther, Marc Knight, and Dan McGuire. I would like to

especially thank Dan McGuire and Eric Gunther for their dedicated work on the system, on the hardware and the interface, respectively. I have learned so much from your work. I find myself some days browsing the "Digi-key" catalog and thinking in code, evidence of my mind stretching.

Laura Packer and Susan Spilecki were great editors. They helped me find the flow of words and reminded me of grammar that I had long forgotten. They helped me get this document to Linda Peterson, the Media Lab's academic administrator, who over the past few years has helped me to navigate through life as a Media Lab researcher. The administrative skills of Tony Pulsone, assistant in Interactive Cinema, had capacitors and boards arriving in a day's time, when a day was all the time I had.

Two mentors, Julie Schneider and Joan Galer, have brought me back to earth and shared their immeasurable, uncensored wisdom. They have given me an ear to bend with every dream and doubt. They fueled me with belief when I needed it. Thanks to my best friends, Mitch Henrion and Linda Post, who listened and listened and listened. Their friendship and ability to make me laugh, over things that minutes before seemed like falling rocks, is priceless. Fee Aulino, friend and sister moon, read rambling emails and listened to creative bursts in the quiet, late hours. My heartfelt thanks to Push Singh for his thoughtful presence, sharp outline editing and hashing through words with me until I found the right expression of an idea.

I would like to thank Kwin Kramer for sharing his research platforms. The project would not have been possible without his previous work and generous research collaboration. Jennifer Smith also contributed to the project in early, in depth research conversations about interaction design.

I would like to acknowledge the generous support, in the design and implementation of Story Beads, of Motorola Corporation and Lego Corporation. Jim Sibigtroth, of Motorola, was a major support in the design and debugging of microcontroller software. Camilla Holten, a friend and designer visiting the Media Lab, taught me some truths about design for children and found the master casters at Lego who redesigned and cast the bead casings.

The girls and young women I have meet over the past two years have been a source of inspiration and a great reminder, to keep faith and take action. Thanks to Cat, Paola,

Jacqueline, Jennifer, Latoya, Carrie, Javaneh, and Tsipora for the stories, the fun and the hope.

Thanks to my family. My brother Tom has shown me courage through his own writing. My Aunt Barbara taught me discipline and daring by following her own path through college. My dad Bill asked me to read my acceptance letter to MIT, word for word, out loud, over the speakerphone, so he and my Mom could be proud of every letter of it. Finally, this work is dedicated to my mom, Dorothy. She stayed in this world just long enough to see the beginning of this work. She taught me the importance of trying, if even only to make a whisper of difference. I did my best.

Table of Contents

1 Introduction

Stories are fluid. Their structure, content and meaning change over time as they move from person to person. This thesis investigates the life of a story as it is fashioned by an artist, author or director and follows it to its internal interpretation by the audience. In a story's journey its elements are reinterpreted to communicate different meanings and in turn create new stories. Conventions of story making are media or container specific. Oral stories, films and photographs have distinct conventions and methods for building stories. As new containers are invented, the activity of story construction, for that particular container, evolves as users find creative ways to express themselves within a new medium.

Story Beads are wearable, computer necklaces designed as a tool for building and trading stories. Digital images are stored on small computer "beads" which can communicate with each other by infrared light for transmission of images. The necklace acts as a database for storing story fragments of image and text. Users can navigate though a collection of story elements presenting them on a special bead, which has an LCD monitor. The users can trade digital pictures from necklace to necklace to share content, their interaction driving the co-construction of stories.

Story Beads allows users to live fluidly with stories by messaging, collecting and building stories as they walk through the world. Stories gain a presence as objects that can be physically manipulated as building blocks of different stories. This thesis proposes Story Beads as a tool for mobile story creation that will produce a unique storytelling process for constructing image-based stories. I call this process *Transactional Storytelling.* Transactional Storytelling is the construction of a story through trade and repurposing of images and image sequences. The trade is between two storytellers who are trading image and text based story elements from their personal collections. Through trading, both the ongoing story and its interpretation by the users is altered as traded pieces are incorporated into a new collection. The first version of Story Beads was designed with special attention to the story construction activities of adolescent girls. Their methods of analog storytelling were incorporated into the design of this project, as they are a group who is inclined to trade and share stories.

This activity of story construction using trade can be seen as an artistic endeavor, a learning experience or a play activity. Our stories can be seen as connections to other people or objects containing memories that define our personal worlds, such as glass beads or photographs. Stories can be our autobiographies and our interactions with people showing how we perceive the world around us.

Story Beads are a tool for messaging in a time when stories and the activity of making stories is becoming distributed, networked and mediated by technology. In this project I am trying to encourage the weaving of digital and analog storytelling threads in a *Distributed Storytelling* space, a space where users can trade both digital and oral stories through trade. Empirical studies over time will show if the tool encourages the construction of story in a unique way.

2 Extended Example

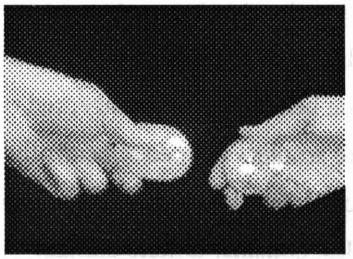
2.1 User Narrative

It is summer in Maine, 2005. Aggie is standing by a tree, taking in the shock of nature on the first day of camp. She is carrying a small blue knapsack with glittery stickers all over it. Coiled around the strap is a long strand of hundreds of tiny beads. Blue beads are for storage; red ones are tiny cameras; green ones are audio recorders; clear beads are amulets or special beads for viewing and trading. The beads contain digital pictures Aggie collected during her recent trip to France, a family reunion where she met everyone -- aunts, uncles, cousins. Others contain collections of images from her friends from school and home. Every once in a while, one of the beads blinks a colored light. Story searchers are zooming around on the strand finding images of her Aunt May. Aggie wants to see the story of May making bread again, the one where the images are aquamarine, like the ocean her Aunt likes so much. Aggie is also wearing a strand of beads around her neck. She takes the blinking blue bead from the strand on her bag and strings it on her necklace. She taps the bead. Images or her aunt cycle by on the small amulet which is a viewing screen.

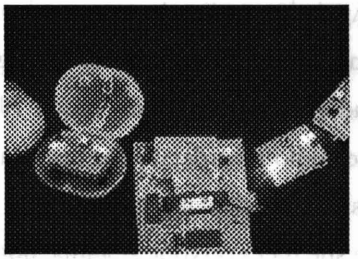
Kira walks by. They say hello and Kira notices that Aggie's necklace is playing out a story. She asks to see it. Aggie shows her. Kira taps the third bead on her necklace and a sequence of images appears showing her mom making cookies last summer. The girls trade a few images, then string together beads from both their necklaces to make a new story where Kira's mom and Aggie's aunt are both in France cooking up a good meal for a group of gypsy travelers. Kira adds pictures from her trip to Canada, as stand-ins for France, since she has never been there. She uses text to describe the image as "just outside of Paris." Kira adds her dog, Buttercup, as the fictional dog, Spark, that leads the gypsies to her aunt's house. A snapshot just taken of the other kids arriving at camp is used as the group of gypsies. They press the beads to show successive images that play out their newly built story. Each girl takes a copy and goes off to settle into her assigned cabin, her home for the next two months.

Over the course of the month, Aggie and Kira build a collection of stories about their families, their friends and their imaginary worlds. Some stories are shared with other kids at camp. Others are saved, their own personal version, their memories of camp. On the last day of camp the girls go on an expedition, walking in the woods, swimming in the lake and saying goodbye to all the friends they met over the summer.

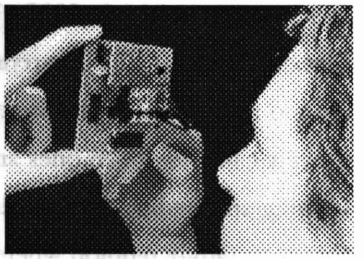
They take the pictures they have collected and each make a story on one bead. They leave their beads in their cabins hoping someone will find them before next year and leave some stories for them to discover next summer.



Trading the pictures



Stringing the story



Viewing the story

3 Theory and Rationale

3.1 Story

Stories are constructed artifacts, woven into memory.

Webster' s Dictionary defines story as "the telling of a happening or connected series of happenings, whether true or fictitious; an account; a narration." Within the scope of this thesis *story* will be a general term used to describe a *narrative.* In Webster's, the definitions of story and narrative are interchangeable. Story is a shape or pattern onto which events or series of events can be organized and understood (Livo, Rietz, 1986). Stories live in and are influenced by their container, the medium of their telling. Containers give a story persistence, committing it to memory. Containers are storytelling performances, novels, poems, computational story systems, theater, collages, films or any other manifestation of story that can be experienced by a viewer or listener. The container influences the telling of the story. In this section, oral storytelling, the novel, cinema and photography will be the focus of investigation of story containers. Story Beads are a container for stories. New conventions for telling distributed stories will emerge from using it as a tool for making stories.

3.1.1 Storytelling

Oral Storytelling is the art of communicating a spoken story to an audience. It is distinct from other forms of storytelling, as it is a telling of an oral literature influenced by the presence of an influential audience. Oral stories from a culture define its beliefs, circumstances and relationship to universal archetypes. Storytelling has a specific function in culture. Livo and Rietz, researchers in the art of storytelling, define a storyteller as

> "someone who can enter into another reality and who promises to negotiate between the audience and that other reality -- to tell the audience into another place and time. The teller operates on the mutually understood ritual that releases both teller and audience from the confines of common routine and expectation. He or she initiates the play that brings the story reality into being through the experience or storying, or story reconstruction."

Storytelling, therefore, is a collaborative process, one in which the teller and the audience share a connection to the cultural origins of the story. The storytelling is not only the oral telling of a story but the process of selecting, preparing and delivering a story to an audience. Delivery of a story is not just the choice of words. It is the style, gesture, intonation and the sprit of telling. In

one of the oldest storytelling practices the teller entered a trance, entering the world between reality and story. In Latina storytelling, one enters the space to summon "el duende." It is described by Clarissa Pinkola Estes, author of "Women Who Run With the Wolves," as "the force behind a person's actions and creative life" (Estes, 1992). The term also means the ability to conjure poetic images in one's mind.

Of the story forms referenced in this thesis, computer-augmented story, by virtue of its flexibility in mediating a story on-the-fly, may be closest in process to that of oral storytelling. A computational story engine uses algorithms to choose elements from a database to build into a story. A storyteller researches the written record of oral history and chooses elements on which to focus her telling. A computer can personalize a story by considering information about the audience and it allows their actions to have consequence in the story playout. A computational form for storytelling acts as a flexible mediator between content and audience, much like an oral storyteller.

In Story Beads, an oral narrative about the transacted image might accompany the trade of a story element. One could think of this as a fragment of a storytelling performance. In the Story Bead system there is no computational engine. The beads store and transmit images as the user demands. The story pieces are chosen, traded and organized in user interaction with the system, not by a computational engine.

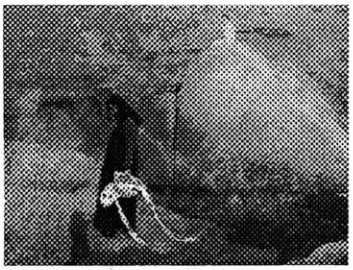
3.1.2 Narrative

Narrative is a story told by a narrator. Narrative can be distilled into two parts: story elements and the interpretation by the narrator. The story elements are called the fabula, the interpretation the sujet. Frank Kermode, a narrative theorist, elaborates on the story conventions of fabula and sujet in his definition of narrative.

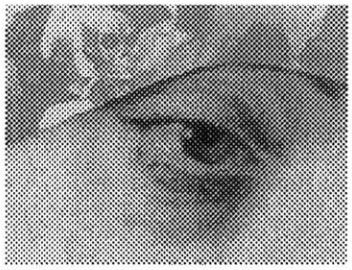
> "...[N]arrative is the presentation of a fable and its progressive interpretation (which of course alters it)...the proposition is not altogether different from the classic fabula/sujet distinction."

In this case interpretation is meant strictly as the construction of the story by the narrator to communicate a certain meaning, not interpretation by an audience. One could think of fabula as a list of what happens in the story -- a woman stands on a cliff, she is pushed off, she falls into the sea, she turns into a skeleton, she lives with the fish.[1]

The sujet is an interpretation by not only sequencing action but other decisions that would affect the story presentation. I am the narrator. Here is my interpretation:



She is waiting. The sun rises

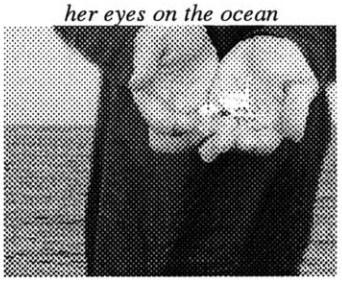


watching from the high rocks

her eyes on the ocean

impact

now she sleeps as fish swim



and her skeleton shrinks.

Some examples of these choices are inference of causal relationships, establishment of a progression of time in the story, choice of point of view and, in the case of cinema, editing style.[2] These choices are related to the container the sujet will take. Conventions for narrative using written word are different from those in film. Filmmaker Akira Kurosawa told the story of Shakespeare's *King Lear* in his film *Ran*. Kurosawa removed all the characters' monologues from Shakespeare's play. He used flashes of images, sometimes silent dream-like montage sequences, to communicate their thoughts.(Kurosawa, 1985) In the case of Story Beads the fabula would be a collection of images on a necklace. The choices for construction of the sujet would be the sequencing of beads, the descriptions of images and the oral storytelling element that might accompany a trade of a story fragment.

Story is an observation or imagining put into a symbolic system of language or image in order to be understood by a reader or listener. Part of the challenge of the author is to describe what she sees in a way that conveys the meaning she intends. The audience will interpret stories in different ways as individuals map their own experiences onto the symbols and images they are given. Stories are open to infinite interpretations.

"In the Spring of 1924 the young German physicist Werner Heisenberg went on a walking tour with the great Neils Bohr in Denmark, Bohr's homeland. The following is Heisenberg's account of what Bohr said when they came to the Kronberg Castle.

> 'Isn't it strange how this castle changes as soon as one imagines that Hamlet lived here. As scientists we believe that a castle consists only of stones, and admire the way the architect put them together. The stone, the green roof with its patina, the woodcarvings in the church, constitute the whole castle. None of this should be changed by the fact that Hamlet lived here, and yet it is changed completely. Suddenly the walls and ramparts speak a different language. The courtyard becomes an entire world, a dark corner reminds us of the human soul, we hear Hamlet's "to be or not to be."' (Mills, 1976)

This quote, from a book called "Possible Castles" by Gordon Mills shows how we imbue objects with stories and stories with meaning.[3] (Bruner, 1986) We all know that the Kronberg Castle is a real place and Hamlet is a fictional character, yet in Bohr's viewing of the castle the two worlds collide. He has taken a symbol from Shakespeare's story and related it to his own experience, a leisurely walk with Heisenberg. Heisenberg, I suspect, will never think of that castle again without recalling Bohr's story or Hamlet's.

Not only the sequencing of events or the selection of symbols, but stylistic choices are also part of building a sujet. In film, the camera-eye, or how the camera is situated and each shot framed, is an integral part of storying in film. In Alfred Hitchcock's films, he uses a montage of close-ups to create the emotion of suspense. In his film *Rear Window* when Jimmy Stewart falls from the window, fall is communicated by montage of close-up images -- arms, legs, and heads, instead of a long shot of an entire body falling from the window to the ground.[4] (Bogdanovich, 1963) In the film *Barton Fink* the director, Joel Cohen, use camera angle as a device to show character point of view (Cohen, 1991). The scenes seen through the eyes of one character are always shot from above looking down on the subject; those seen by the other character are shot from below looking up. These camera angles not only infuse a psychological element to the personality of each character, but allow the viewers a clear vehicle to distinguish between characters and adapt their contextual interpretation of each scene.

In the case of Story Beads, the sequencing and association of images is the main method of constructing stories. The description of individual images and repurposing of images allows for crafting a story point of view or style. The adoption of cinematic techniques is contingent on the

ability of a set of photographs to communicate using cinematic techniques such as juxtapostion and montage. When the images are traded from user to user it creates an opportunity for still images to inspire oral stories. In the case of Hamlet's castle, the system allows images to be tagged with multiple meanings. If they were both wearing necklaces, a picture of Kronberg Castle could have been traded from Bohr to Heisenberg, silently, while they both took in the view of the majestic castle. The image would have then been traded to Mills, then to Bruner, each of them their adding our own interpretation of the castle symbol and its part in their story.

3.1.3 Autobiography

Gertrude Stein, a novelist, believes content drives the structure of a story – there is no formula.

> "Narrative will be, as always, what Stein described as 'anyone telling anything to anyone at anytime' so that narrative as a pure concept will not change. What will change is the manner of that telling." (McCaffery, 1992)

Stein's ideas about writing stories relate to the story building encouraged by Story Beads.

Simultaneity and fragmentation. Stein, through her discussions and allegiances with the Cubist movement in painting, believed in fragmentation as a device to reveal more views within a story. Reality in a story can be broken down into fragments and viewed from shifting angles, just as in the Picasso's Cubist paintings. In his pre-Cubist work Picasso painted a portrait of Stein. She sat for over 90 sessions over a year while Picasso worked and reworked the painting, Stein's image depicted hundreds of times on one canvas until Picasso settled on a mask-like portrait. Picasso would eventually move to Cubism, where multiple points of view of a subject are all presented on one canvas. The pieces are extracted from observing the scene, then pasted together side by side on a two dimensional surface. Every point of view is seen simultaneously. The necklace, as an entire database, is a view of all possible stories. In the realm of storytelling this fragmented, multiple-view approach breaks down the notion of linear plot. As Stein uses this method to construct stories, her narratives are essentially autobiographical collections of story fragments. Story Beads are containers that house collections of story fragments.

Autobiography. Stein sees the telling of a fictional story or an account of a true story as inextricable from the time in which it is told. In her work, the form of the story emerges as the everyday life weaves into the constructing of the narrative. The combining of documentary time, meaning the time of writing and fictional time, the depiction of time in the story, creates a new story form. To Stein all stories, due to the nature of telling, are autobiographical.

"With Stein there is a technical advancement and in her notion of the continuous present we find a severing of the first from second term and an abandonment of that second term (the world becomes totally subjective)." (McCaffery, 1992)

In the case of Story Beads a user's original images and descriptions can be seen as fictional time, the time of the initial story authoring, while the images acquired by trade and repurposing can be seen as documentary time, the time of the delivery of the story to another person. The arranging of story by stringing together images from both times creates a new story form. In the case of Story Beads, each fragment of story has its own set of metadata which shows how it has been described over time. This is documentary time. Each traded image keeps the phrases that different storytellers have used to describe it. Not only can each story contain fragments that depict multiple views but each fragment can also be viewed in multiple ways through its descriptive history. If Picasso had photographed the Stein portrait after every sitting, he would have a history of how he described her in each painting session.

3.1.4 Sequential Story

Sequencing images is a tool for storytelling used in forms such as cinema and comics. We, as viewers or readers, use unspoken conventions to interpret a sequence. For example, when we view an edited film we do not see it as 300 individual clips -- each its own small, separate story. We view the story as a progression of scenes. How do we know when one scene ends and another begins when there is no obvious signal, such as a bell ringing, to tell us a new scene has begun? We use conventions of story to infer that one segment of action has ended and another will begin. There might be a change in setting, a change in character point of view, a change in time. A story is interpreted by observing each individual piece of story content (each frame of a movie) and constructing the story sequence through a series of context shifts. In cinematic storytelling the juxtaposition of images and their concatenation into scenes forms the story.

Lev Kuleshov, a cinematic theorist and documentary filmmaker, was the first to articulate the relationship between elements in a cinematic montage. A montage is a sequence of short scenes or images arranged in a pictorial composition to communicate a theme. Kuleshov's study of juxtaposing images to create meaning is one of repurposing. A meaningless shot can be taken and later, when placed before another shot, it acquires a specific meaning. The two shots together are interpreted as occurring in the same story space.

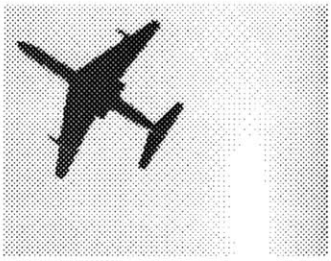
"The famous 'Kuleshov effect' with Russian actor Mozhukhin affirmed the speculation. Having found a long take in close-up of Mozhukhin's expressionlessly neutral face, Kuleshov intercut it with various shots, the exact content of which he

himself forgot in later years -- shots, according to Pudovkin, of a bowl of steaming soup, a woman in a coffin, and a child playing with a toy bear -- and projected these to an audience which marveled at the sensitivity of the actor's range." (Kuleshov, 1974).

The communication of the story comes from defining a sequence as the relationships between neighboring images. Using Story Beads, still images can be sequenced to create stories. The images can communicate the story solely by visual impact or can be supported by words as in Comic strips, a pictorial novel such as Dorothy Allison's *Two or Three Things I Know for Sure*, or a film told in still frames with narration such as Chris Marker's *La Jetee* are examples of text and image based stories expressed in different media.

In comics, words often accompany images and can change their meaning. Scott McCloud defines the different uses of text image association in "Understanding Comics" (McCloud, 1993). His categories are the following: (1) Word specific combinations - where the words illustrate the content of the picture, (2) Picture specific combinations - where the words add a soundtrack to the picture almost like sound effects, (3) Duo-specific - where words and pictures communicate the same message, (4) Additive combinations - where the words amplify the image, (5) Parallel combinations - where words and pictures describe two different tracks of story and (6) Montage - where the words are used as actual pictorial elements. McCloud sees the relationship between images and words in comics as a delicate balance between telling and showing. The combination of image and word is able to communicate a more complex message than either one alone. In Allison's novel, pictures are used to amplify the works of the story of her family and growing up in South Carolina. Her use of word and image is different from McCloud's. She uses images to support her words, while he uses words to support his images. Chris Marker uses voice-over narration as a thread of story that is depicted in still pictures. Some sequences are silent juxtapositions of images.

Others include narration to add story detail to images that need to be fit into the story context.



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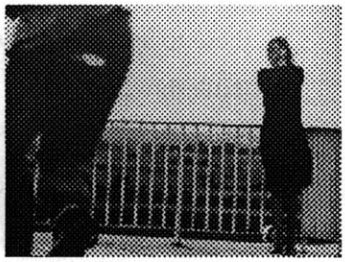
The sudden roar, the woman's gesture



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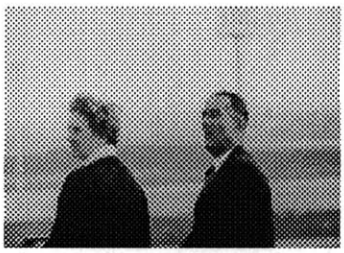
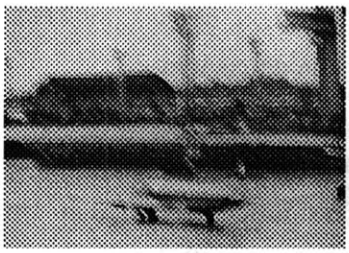


the crumpling body, and the cries of the crowd on the jetty blurred by fear.



Later he knew he had seen a man die.

And sometime after came the destruction of Paris.

In Story Beads the sequencing of images and the text description associated with images allow for a flexible set of content.

3.2 Play

Play functions as a tool for the development of self and social understanding.

3.2.1 Nature of Play

Play is social. It is a mechanism for cognitive development and for understanding the social construction of the world. Katherine Garvey, a social psychologist in her book *Play*, defines play as a social activity with inconspicuous goals, goals not obvious to an observer. Play is an activity disassociated from the consequences of real world actions. Play tightrope walking removes the height of the activity. There is nowhere to fall. This shift in circumstances of the play action removes the dangerous consequences of falling. This contextualization shows the ability to shift between two mental models – one reality, one fantasy. As children grow from early to middle childhood, the function of play expands to include the formation of complex social relationships. Friends and social groups are formed through the process of play. Delayed mimicking of actions and object focused play are replaced by complex narrative interactions with peers. Simple sequencing of objects and elements of fantasy narrative become more complex as concepts such as causality, condition, and irony in construction are introduced.

Play is also solitary. D.W. Winnicott, a psychoanalytic theorist, saw play as a tool for self-discovery. The objects used in play are containers to fill with meaning. For example, a young child, as a way to individuate, might choose a specific toy plane or story character and mark it as more important than the parent. The symbol serves as training wheels for the child to internally ride away from the parent to autonomy. Each play object has a story. As life changes, the meaning attached to the object changes.

Winnicott investigates play activities and their consequences for ego development. Self-discovery is the result of a process. First, relaxation allows the mind to move into a chaotic and nonsensical state or space. Stories generated in this nonsensical space contain a grain of truth about the self. Then, when the truth is spoken and mirrored to another person, in Winnicott's world the parent or psychiatrist, it becomes integrated into the personality. In Winnicott's view, play is self-explanation.

3.2.2 Play and Learning Styles

Different people are inclined to different styles of play activity. On entering a room full of toys and games some children will move toward construction toys such as Lego, others towards games of strategy such as Pokemon, and still others toward theatrical role-play such as reenacting their favorite scenes from *The PowerPuff Girl* cartoons. The world of play is broad and diverse. The epistemological studies of play focus on different play styles and their association with developmental stages. The stages described by Piaget are imitative, sensory, symbolic and rule-based. The two latter stages are invoked in the construction of story. Symbolic play, according to Piaget, begins at the age of two when a child begins to make distinctions between fantasy and the real world (Revenson, 1978). In symbolic play the real world is accommodated into the play world. If a child is role-playing as a PowerPuff girl and the real world telephone rings, she can imagine the ring is a signal from Blossom, the leader of the PowerPuff gang, to rally to save the world again. Rule-based play can incorporate story elements generated in symbolic play that are negotiated by members of the playgroup. In rule-based play one member of the group might assert that in all flying scenes any words must be sung for the other Puffs to hear them. Negotiation over this rule leads to community elected decisions about the process of storytelling in the imaginative play. Symbolic and rule-based play are tools for story construction.

In their work on epistemological pluralism, Sherry Turkle and Seymour Papert of M.I.T. make a connection between play styles in learning and gender. They argue that the basic elements of computation should be expanded to include the two styles of learning they described as "hard" and "soft." "Hard" describes a logical approach to problem solving using abstract thought and

systematic planning typical of computation design. "Soft" describes a non-linear, bricolage approach to problem solving using manipulation of ideas and objects to find an emergent solution. Turkle and Papert found that, although individuals possess the ability to use both learning styles, girls are inclined to favor the "soft" approach. Girls are discouraged from participation in computation culture which places more value on the "hard" style. Story Beads was developed as a tool that allows the user to shift between "hard" and "soft" styles. The "hard" style can be viewed as rule-based play, the "soft" style as improvisation. An example of a game that incorporates both styles is hopscotch. There is a rule for physical movement on the hopscotch grid: get from one end to the other. The players often make up improvisational rhymes as they jump from square to square the rhyme echoing the rhythm of the player's feet hitting each square. In Story Beads, there are not rules, but there is an interaction design. Images are copied from bead to bead when traded. Individual beads cannot hold more than eight images. These constraints influence the story construction activity. The beads are "soft" in that they allow spaces for improvisational oral storytelling during the trade of images. They also encourage the bricolage style as images can be sequenced and resequenced by stringing beads together.

3.3 Construction

We construct knowledge by building stories.

3.3.1 Constructionism

In the context of this thesis, construction is defined as the epistemological term "constructionism." Constructionism is a concept developed by Seymour Papert of M.I.T. It extends Constructivist theory, which states that all children construct their own knowledge. Constructionism expands on this concept by claiming that children have many of their best learning experiences when they are actively engaged in making a product or artifact, which is meaningful to themselves or others (Papert, 1991). In the constructionist experience, the environment responds to the builder, giving her feedback during the process of learning. An example of constructionist learning is a child building a scale out of Lego bricks to learn about weight, balance and gravity -- building a flexible object to learn about a concept or idea. Constructionism refers to the creation of all types of artifacts, not only physical objects but also images and stories. Manipulating reusable and redescribable images as story fragments, learners investigate different story structures, and different ways of expressing their fictional, documentary or autobiographical narratives. By trading sequences of images, or single images, they learn how other storytellers describe images and build stories.

3.4 Trade

Stories flow between people and objects collecting histories that define culture.

3.4.1 Object Transactions

If objects have energy associations, as described by Mihaly Csikszentmihalyi, a professor of psychology at the University of Chicago who studies object relations, then trade of an object transforms its state. In his description of the relationship between people and objects, "cultivation" is used to describe how mediation between people and objects creates meaning (Csikszentmihalyi, 1981). He breaks a transaction down into three modes: aesthetic quality, channeling of psychic energy and outcome of the transaction. Aesthetic quality is our perception of an object. When we view something we have an idea of how the object functions in the world by comparing it to other objects we know. In StoryBeads the reference to a bead could bring up a schema that includes stringing together and trading because those activities are attributed to the history of beads as objects, and thus our perception of them. Psychic energy is the amount and type of attention invested in an object. A chosen object has more psychic energy than a discarded one. A child's favorite stuffed animal has more psychic energy than a forgotten crayon. In the case of StoryBeads, as with other objects, a trade channels the psychic energy of the object from one owner to another where it is revalued. There is a flow of energy between the traders and the traded. The outcome of a transaction reveals the goal that was intended in the trade. This transaction involves a relationship over time in which an object is valued. For example,

> "Thus when one values a cherished photo, or souvenir or plant, these transactions are intentional activities that reflect what one considers significant and which involve real outcomes." (Csikszentmihalyi, 1981).

Transactions are person to object and person to person, through objects. The objects are transformed when they are traded. The goal of the transaction, the intended use of the traded object, and the relationship of the individuals making the transactions all contribute to the transformation of the object.

3.4.2 Story Transactions

People trade stories. Historically, folktales were passed from generation to generation defining cultures and keeping their histories alive through the human transactions of storytelling. This evokes the image of inter-generational exchange of stories by fireside. Story transactions also happen in our everyday lives in the form of messaging. Often, they are not a complete story but a reflection of the moment in which they are told. Following are some examples of narrative and object interactions, which are story transactions:

- Trading a Pokemon card is the story of your identification with the characters and the value we place on the card and our relationship to person we are trading with.

- Giving someone something a gift is story as the art of considering a friend or acquaintance by exchanging meaningful objects. It is a reciprocal art that generates trade over a period of time. A gift will often be given as appreciation for a gift received.

- Leaving a message on voicemail is the story of the moment the message is left heard later.

- Debating a peacekeeping policy at the United Nations is the story of individual opinions about how a conflict could be resolved. each storyteller speculates about an outcome to the conflict.

- Telling someone a story that your great grandmother told you is the story of where we are from and building or identity within a family and culture.

- Having your groceries bar-code scanned at the supermarket is the story of what you intended to buy on our grocery list transformed into the grocery store's account of what you purchased. Stories can be inferred from you we buy. If you buy a larger quantity than usual we might have houseguests or if you buy cat food, you probably own a cat.

- Buying a book because of a review you read on amazon is the story how the book might affect us. We consider the story experience of the reviewer.

- Asking for directions is the story of how we move to get from one place to another.

This notion clearly uses Stein's definition of story as ever-present narrative. The examples above range from the articulation of a complete story, one which has been given to us, to a narrative gesture, which can be used in a broader story context. They are stories as pieces of our experience that we trade as we strive to understand the world around us.

The idea of Transactional Stories was inspired by a theory of Jerome Bruner, a cognitive psychologist from Harvard University. Transactions between people generate an understanding of their culture. Here is how he defines a transaction:

> "This is not an easy word to define. I want to signify those dealings which are premised on a mutual sharing of assumptions and beliefs about how the world is,

how mind works, what we are up to, and how communication should proceed."
(Bruner, 1986)

Bruner acknowledges that narrative is a transactional activity affecting story state. Our beliefs, assumptions and descriptions of "what we are up to" can take the form of a story. When I tell the story of apple picking to a friend, the state of the story is established. The object of the apple farm has an image in my mind that is used to generate a story. This is a change of story state. I have taken my experience of apple picking and narrated it. Bruner's theories can be extended to include the repurposing of story by the audience. When my friend hears the story, she creates her on frame for it, based on her experience. A new story is generated. This is also a transaction.

As we move through the physical or digital world our interactions with pieces of information create stories. By trading a Pokemon card we are telling a narrative both about the character and about our own identification with it in the present game situation. By leaving a phone message we are telling a story of what a conversation would have been if there were a listener on the other end. The listener finds the story later. In Japan giving a gift is a transaction that has been elevated to an art form. These transactions are connected to us directly, as if in a face-to-face conversation, or indirectly if we are represented in another form, such as text or a computational structure. These transactions of story are colored by our intentions in telling and by the information that we are conveying. Each trade alters our model of the world, however subtly, and transforms it. Through these exchanges both the story and the teller has been changed. Through this exchange of ideas and intentions we create socially constructed stories, transactions that alter how we see our own situations, histories and relationships.

3.5 Photography

Photographs are visual stories captured in time.

3.5.1 Image

Photography is a means to capture an image. The technical history and process of recording a photograph, while interesting, will not be discussed in this thesis. Here the photograph as an object of representation and the photographer as a collector and organizer of images are the main concerns. Every photographic image has the potential to be a story or part of a story. The photographer communicates a story by choosing, composing and presenting a photographic image. Just as oral stories and cinematic stories come into existence when they are authored, photographs require action that transforms them from an image to a story. Ansel Adams a

prominent landscape photographer and conservationist, describes the container of a photograph and the conditions necessary for story.

> "The negative is the equivalent of the composer's score, and the print the performance." (Adams, 1999)

When the picture is shared with an audience, when the performance happens, the number of stories is increased by the number of people in the audience, so each interpretation becomes a new story. Therefore, in the case of photography and a performed score, the story told to the audience is constructed. The story built by each audience member is co-constructed, by the initial author, the photographer, and the secondary author, the audience member.

Recording an image intended for a sequence, as in film, is different from taking a picture to tell a story. Documentary photographers, use a single image to instigate story construction. Some, such as Henri Cartier Bresson, wait for the moment of change in a situation as the exact time to photograph. The shift of action delivers the optimum number of triggers for our minds to interpret the contents of the photograph and understand the context in which the photograph was taken (Michell, 1992). Others focus on a still subject as the means to reveal a story. Our identification with the subject catalyzes the story.

In 1894, photography became accessible to the general public as a form of recreation and personal documentary-making through the introduction of the box camera by George Eastman. Mass production of the camera democratized our experiences by translating them into images we could share (Sontag, 1973). It became possible to catalog the moments of a life by capturing images anywhere, not just in a photographer's studio. Photographs were seen as evidence of a life lived depicting the truth of the moment in which the photograph was taken. By showing a photograph, someone can share the experience of seeing an image. Not only the contents of image but the sensibility of the person who recorded it are shared. John Berger, a novelist and art critic from London, reflects on how this mass production of photographs impacts the meaning of images. In his case, he uses a photograph of a painting as an example. But the content of the photograph is not the power of his point; it is the transfer of an image through electronic media to its new owner.

> "When the camera reproduces a painting, it destroys the uniqueness of the image. As a result its meaning changes. Or, more exactly, its meaning multiplies and fragments into many meanings.

> This is vividly illustrated by what happens when a painting is shown on a television screen. The painting enters each viewer's house. It is surrounded by his wallpaper, his furniture, and his mementos. It enters the atmosphere of his family. It becomes their talking point. It lends its meaning to their meaning. At the same time it enters a million other homes and, in each of them, is seen in a different context. Because of the camera, the painting now travels to the spectator rather than the spectator to the painting. In its travels, its meaning is diversified." (Berger, 1973)

In the case of Story Beads, the images housed by the wearable computer are not organized in photo album form. They exist as all the possible photo albums that one might present from all of their photographs taken over time. Organization, presentation and distribution of digital images on wearable computers change the possibilities for assigning meaning to the images that we collect. An image has a different meaning if I present it to you from a personal collection that I am physically wearing than if I broadcast it to a million people. There is a personalization in the presentation and the ability to immediately acquire, own, and create meaning from a collection of photographs. Both the places and the people we encounter in our everyday lives become possible experiences for us to tour and glean images from. Trading digital Story Bead images is different from trading analog images, such as pages torn from a magazine or baseball cards, because each image is copied to its new destination and when copied contains quantitative and qualitative data about the image. Story Bead image metadata includes the number of times the image has been traded and the descriptive phrases that previous owners have used for the image. The historical data is part of the object.

3.5.2 Collections

Why do people collect photographs? They use them to construct a reality, a story reality. The narrative exists as a series of images, not exclusively a expression in words. Susan Sontag describes how a family might use images to construct their story.

> "Through photographs, each family constructs a portrait-chronicle of itself – a portable kit of images that bears witness to its connectedness." (Sontag, 1973)

We live in a world where information is distributed. Families connect on the web, via email and cell phones. The notion of connectedness is changing. By using collaborative construction environments, like photosharing websites, groups can redefine themselves continuously. Identity and connectedness within a group is established by interacting and sharing of the evolving portraits or stories. By collecting and sharing images we construct and share our version of the world.

3.5.3 Digital Elasticity

Digital technology is adding a layer of elasticity to the photographic process. Pedro Meyer, a digital photographer, recently told a story clearly unveiling how conventions of taking photographs can be removed by the use of digital imaging. He was hired to shoot a series of photographs to advertise a motorcycle. The advertising agency designed the image in a rural setting, a field with trees, deer and snakes. Pedro could have designed the photograph and constructed it remotely using stock photographs from his collection and a high-resolution image of the motorcycle provided by the client. Instead, he was flown to a remote location in the mid-west and accompanied by stylists lugging the motorcycle, stuffed deer and tress to the grassy location. The ad agency and crew were trying to construct the reality of the image in the real world in order to capture it. With digital photography the notion of capturing an image as a moment in time is destroyed. Photos no longer necessarily reflect reality; Pedro could have built a convincing photo by collaging stock digital images on his computer. We the viewers might never have known it was not real.

3.6 Objects

Objects can contain stories and encode stories.

3.6.1 Object Relationships

Objects have lives, and as described in the previous sections on play, are imbued with meaning by the people who own, see or come into contact with them. Csikszentmihalyi has studied object relationships and done extensive classifications of everyday objects and how people use and regard them. Objects, when classified in one's mind, take on a psychic energy (Csikszentmihalyi, 1981). This is not to say that the objects are personified, but have defined meanings and create a network of meanings for an individual. In his studies, he interviewed 315 people regarding the objects in their homes. He created object categories, which included photographs and jewelry, and assigned uses and meaning to classes of objects. Photos are classified as contemplation objects, mementos, souvenirs and collections having to do with self, family and world. Jewelry classified in style and memento. Csikszentmihalyi's classification schema is too extensive to explain in detail in this thesis, but his studies do show that objects have varying uses and meanings in peoples lives. The photograph holds a special place among objects.

> "More than any other object in the home, photos serve the purpose of preserving the memory of personal ties. In their ability to arouse emotion there is no other object than can surpass them; they are perhaps equaled only by stereos mentioned by the youngest generation."(Csikszentmihalyi, 1981)

In these studies photographs diminished in importance when the interviewed person was of a younger generation. Children found photos to be only one tenth as important as their grandparents. Today, instant connection has claimed importance, particularly with adolescents and teenagers. The importance of the stereo and the photograph has been replaced with cell phones and instant messaging. Instant messages have become objects in their own way.

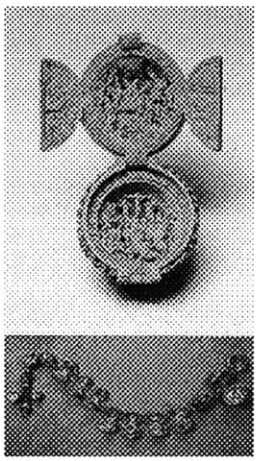
3.6.2 Beads

Beads were invented forty thousand years ago, long before writing, photography or computers. They have different functions in different cultures. Some function as religious artifacts like rosary beads, some as standard units of trade in barter, and others in rituals such as the insurance of entrance to the afterlife. Aside from their aesthetic classification as adornment, beads can tell us information about the culture in which they are made and used.

> "They have been significant to people from Neolithic Asia to twentieth-century New York. They are and have always been used to state basic relationships to life and the supernatural. People have used beads to organize and symbolize their world. They have been guideposts in human relationships and expressions of innermost feelings." (Dubin, 1987)

The word "bead" finds its root in the word "bede" a medieval word meaning prayer. Strands of beads are used in over two-thirds of the worlds religions as a device for prayer counting. People are able to associate certain prayers with beads of a certain form. The idea for Story Beads was developed after seeing an exhibition of Flemish art, which included a prayer bead, made in 1500. The bead, when opened, revealed an intricate sculpture of scenes from Christian theology.

This bead is evidence of the practice of mapping of images and meaning onto beads.



Flemish prayer beads
circa 1500.

The aesthetic design of beads and beaded objects can encode specific messages. In Zulu beadwork, the juxtaposition of color conveys specific narrative meanings. Blue might mean gossip, red tears, and white love. Some associations are community-wide, others are designed and used between two individuals (Dubin, 1987). Beads, historically, are objects that can contain and communicate meaning. Story Beads uses this cultural association with beads as part of its user interface. The paradigm is ancient, the only differences are a Story Bead, physically imbued with a digital images, much like a flexible boxbead five hundred years later, can store multiple textual references to an image and can communicate with a network of other Story Beads.

3.7 Related Research

Messaging in Distributed Story spaces encourages co-construction of story.

3.7.1 Interactive Cinema

The Interactive Cinema Group at the MIT Media Lab is developing tools and spaces for Distributed Storytelling.

> "The term Very Distributed Storytelling suggests a new medium in which multicast, point-to-point networking and local computation converge to offer a dynamic, morphogenic experience whose form and content emerge on-the-fly as authors, audience and machinery engage in the collaborative co-construction of meaning and experience." (Davenport, 2000)

The extended example in chapter two is very much a type of distributed story. Messaging systems are elements in distributed story experiences where participants can connect one to one or one to many, creating subtle or intense changes in the evolving story they are wirelessly connected to. The Story Beads are a visual messaging system that enables users to share and repurpose content with each other or possibly with another story space, such as the World Wide Web or a sensor driven video installation.

An integral activity in a distributed story system is the redescription of content and the forming of sujet from story bits that are distributed throughout the story world. A recent experiment in Interactive Cinema raises the question of whether people form a story from a sea of images they are unfamiliar with when they don't actively narrate the story to an audience. "Dream Weaver" is an interactive video installation in a public space where video clips are chosen by a user's movement on a sensor carpet, called the cinemat. The cinemat is placed in front of the video projection, where successive video clips playout. Two versions of the "Dream Weaver" project investigate the question of story construction. In "Dream Weaver" installed in Rotterdam, people cut sequences of video, alone or in pairs, by stepping on the cinemat. In the version in Mexico, an audience of 100 watched the person on the carpet while another member of the audience told a story. Right away the storyteller incorporated the person on the cinemat into the story as a character. As the person moved and the video clips played out, the storyteller built on the story. Laughter would emerge from the audience when an image did not fit the teller's tale. In Mexico, the two parallel threads of story, sequencing of images and oral storytelling, supported each other to present a story to the audience. There was co-construction. In Rotterdam it was uncertain whether the users constructed story or not. The cinemat participants in Rotterdam may have been simply browsing through a collection, which is not storytelling.

Story Beads have a construction activity similar to "Dream Weaver." Although sensors do not trigger presentation of story elements, elements are strung together. Image sequences can trigger the co-construction of story or a collection of images can simply be browsed with the possibility, but no evidence, of the user's internal construction of story.

3.7.2 Tradable Bits

Story Beads is directly related to a body of work called "Digital Manipulatives" that is being researched by the Epistemology and Learning Group at the MIT Media Lab (Resnick, 1998). The work is Constructionist in that it expands the range of things that children can design and build using mathematical and computational concepts. They learn in the process. Physical objects like badges, blocks, tiles and beads are imbued with computation giving them behavior and the ability to communicate with each other, usually by infrared light. Some of the physical

objects can be programmed by the children, while others are used as fixed construction blocks. Their research also looks at play as a way to learn about systems. The tiles, a project by Kwin Kramer, uses rectangular tiles as elements that can teach about emergent behavior by communication of a set of tiles via mobile code. For example, if a child puts down a set of ten tiles on the floor, nine tiles have a program which will blink a red light then pass the program to its neighbor, one tile is programmed to flash a green light and render inactive any red-light-flashing programs it encounters, and then move on to a neighboring tile. The child sets all the programs in motion and sees red lights jumping, green lights jumping and swallowing the red lights. The child activates programs on tiles more than one time, seeing that setting 10 green light programs on to the system will kill all the red lights or that adding a delay in to the red programs gives the child time to take the red tiles out range of the jumping green light, before it is deleted. A game is created. Children can see patterns of behavior in the tiles that they can then alter to investigate a hypothesis (Kramer, 1998). In much the same style as the tiles, Kramer's prior work investigated beads as interactive objects for children to explore abstract ideas.

Story Beads do not use observation of behavior as a way to discover and learn. They use emergent patterns in narrative and allow people to share images and experiences. They are more of a construction set for collecting and building, than for observing and hypothesizing. Their focus is on trade between users as a network, where tiles trade code between objects. The objects are a sharing community apart from the users.

Rick Borovoy, of the Epistemology and Learning group, coined the phrase "tradable bits" to describe the phenomenon of messaging between objects in his research. His work includes meme tages, badges that allow wearers to exchange bit of information about themselves and "i-balls," handheld devices that allow the trade of icons to create games of community interaction (Borovoy et al., 1998).

3.8 Gender and Technology

Encouraging open-ended narrative expression.

3.8.1 Why Girls?

In my work at Girls Day, an after school program for girls at the Computer Clubhouse in Boston, an after-school program for girls to learn about technology, I observed girls telling stories around technology, not through it. Here is an example.

In a workshop using small programmable computers called "crickets," which can be programmed using a computer language called Logo. Groups of four girls were each given

Legos, craft materials and a cricket, which was pre-programmed with one reaction triggered by a sensor. When the light sensor of the cricket was covered, a motor attached to the cricket began to turn. When the light sensor was uncovered the motor stopped spinning. They used the materials to build magnificent scenes and sculptures, an amusement park with a Ferris wheel, a cat with moving whiskers and a fantasyland with spinning flowers. The crickets were the jumping off point for a narrative experience which ending when the sculpture was finished. The girls saw the sculpture material as flexible, cutting felt and foam to twist it into cats and wheels. Although they knew it was possible to reprogram the cricket, not one of the six groups altered their crickets' behavior.

The story activity uses fixed and flexible materials for construction. The materials have different levels of flexibility. If each group of girls had been given a set of crickets each with a distinct pre-programmed behavior the possibilities for narrative expression would have been expanded. At another level of engagement with the materials, the girls might be encouraged to alter the behavior of each cricket to fit what they imagined the scene to be - the Ferris wheel moving faster or the cat making a sound while its whiskers moved. The girls understood the crickets as programmable computers. They had, in fact, programmed them the week before, and created different cricket behaviors using Logo. When constructing narrative, they did not integrate this knowledge to expand the possibilities for narrative by expanding the story by altering cricket behavior. Just as felt can be seen as material for building sculptural narratives, by cutting it into shapes or drawing on it, computers have the flexibility to sculpt narratives by offering flexible behavior in a construction material.

The agent software for Story Beads was meant to give girls a way to investigate how to tell a computer to search through a network of beads to find and retrieve a story element. The ability to program a bead, in the way a cricket is programmed, was not implemented in the first Story Bead prototype.

3.8.2 Design for Girls

Design of technologies for girls is usually content directed. For example, Brenda Laurel of Purple Moon, a software company that produces computer games for girls, was motivated by a desire to use computer games as a vehicle to introduce girls to computers. She interviewed over a thousand girls ranging from the ages of seven to twelve. She asked their opinions about computer games. She found that girls were interested in a specific social currency in their games (Laurel 1998). They like experiential paths. They don't like being trapped in puzzles for a long period of time or being killed within the first few minutes of a game. The feedback from the girls was built into the design of a game featuring a girl heroine of the everyday, named Rocket.

Rocket's adventures take her through tribulations and successes at school, finding her role among her peers and problem solving in story spaces, such as a forest where girls tell their secrets to each other. This is one approach to using technology to build applications that are useful to girls. It is directed content and activity meant to mirror girls' actual lives, to include them in computer culture. The games generated interest with girls and created a space for a serious consideration in industry of girls as computer users.

Story Beads does not have a specific content base for girls to relate to. It is an activity and tool for girls to tell stories about themselves and the culture they live in. The focus is exploring oneself through personal narrative. Having a system with open content, girls can build their own individual narratives. They can express who they are and, by trading, incorporate aspects of their friends, family and environment into their stories. Fixed content games for girls often give a static, traditional narrative role for girls. Whether the role is Barbie, Rocket or Laura Croft, the users have in each case a stereotype for comparison. A system such as Story Beads gives girls space to reinforce their individuality. It encourages diversity. Story Beads is not gender exclusive. The Rocket games were intentionally directed to a girl market to prevent the game being trashed by a boy audience with a different sensibility and notion of a "good" computer game. Adornment using beads and the construction of narratives are not gender specific, boys might wear Story Beads but use them in a different way to make stories. Making the computer in the form and function of beads, familiar objects that are popular with girls, is a way to get them interested in computers to play, the way boys are usually introduced to them through computer games.

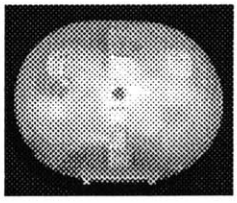
4 Design Evaluation of Story Beads

4.1 System Overview

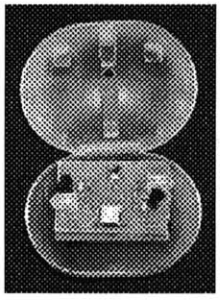
Story Beads consists of a series of storage beads and an amulet bead. Images are selected in a PC application and are loaded onto individual beads. Eight images can be loaded onto individual beads. Beads can be tagged with metadata, a string that might be the theme of a bead; images will be tagged with the metadata, strings that are textual descriptions of the image, once they are loaded onto a particular bead. Once images are loaded on the beads, the beads can be arranged as if in a necklace; the beads communicate via IR protocols. An image stored on one bead can be selected and passed from bead to bead until it arrives at the monitor bead and is displayed. By holding the image monitor up to another image monitor, the displayed image is able to "jump" across to another necklace. For technical and implementation details, please see the Appendix.

4.1.1 Storage Beads

Storage beads are the destination for images downloaded to the necklace from the desktop application and traded images downloaded by the amulet from a different necklace. By pressing the push button on a storage bead the user sends one image, packet by packet, to the amulet bead to be displayed. The users can cycle through each of the four images on each storage bead by pressing the push button. If a bead is full, no other images can be stored unless an existing image is deleted. Storage beads can also be used to trade images between users, although images cannot be seen before trading. Storage beads can also be physically traded between necklaces. If one user gives an entire storage bead to another user the new bead is integrated into the new necklace by simply adding it to the string of beads. Storage beads are user specific by virtue of the image data they contain, not by a hard coded user identification number. Storage beads are encased in plastic containers. The containers allow for infrared transmission between beads.



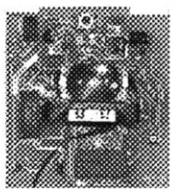
Closed storage bead



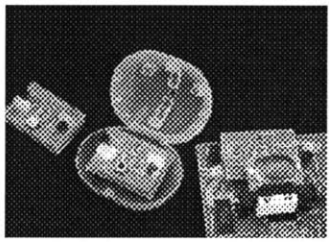
Open storage bead

4.1.2 Amulet Bead

The amulet bead is used for viewing and trading images. When a storage bead is pressed, the current image selected is sent to the amulet bead where it is displayed on a mini LCD monitor. The amulet interface has three push buttons. One deletes an image and one sends an image to another necklace via the third infrared to another amulet. The third toggles the LCD screen back and forth between viewing an image and its associated text. When the amulet receives a new image from another amulet it will send it the storage bead. This destination storage bead is chosen by pressing its button.



Amulet bead for viewing and trading.

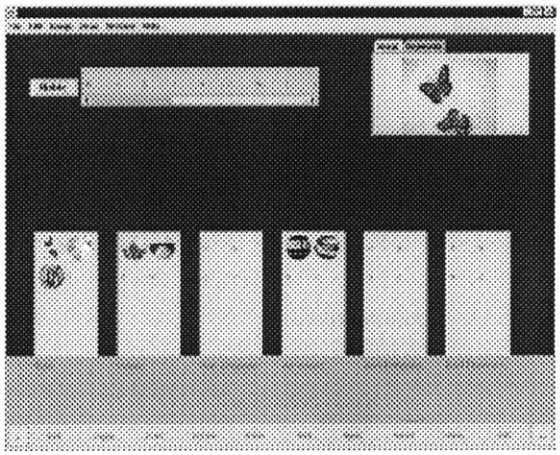


Storage bead passing an image to the amulet bead.

4.1.3 Desktop User Interface

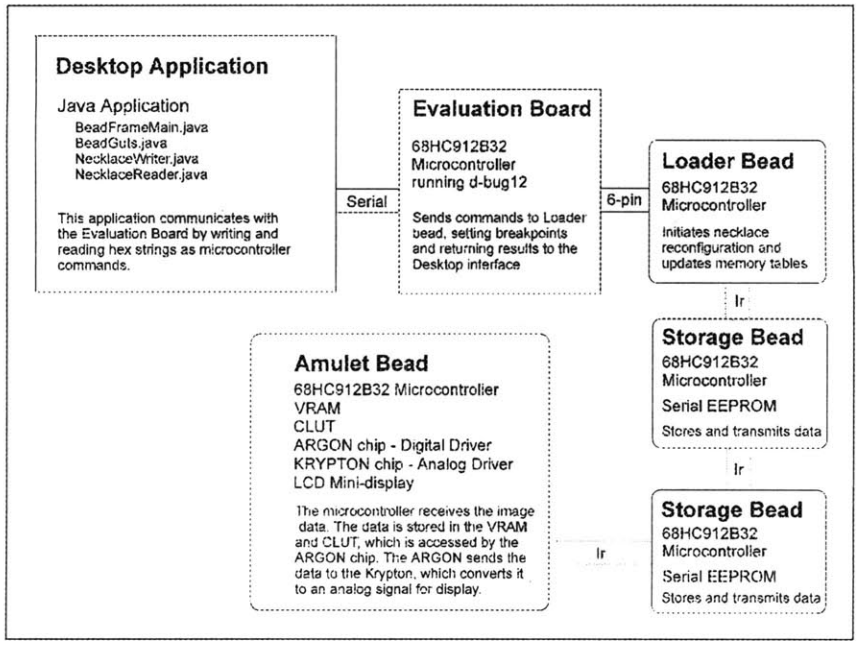
The desktop application is used for organizing images and downloading image files to the beads. In the graphical user interface the user can organize images by describing them and putting them into containers that represent individual beads. There are two ways to describe Story Bead images. Images can have textual descriptions attached to them and are also associated by the keyword of the bead that contains them. Each bead is given a thematic keyword. Thematic keywords are single words used to describe the contents of a bead. For example, a bead with a thematic keyword "flying" might contain pictures of bugs, birds and airplanes. When images are placed in a bead container they are tagged with that bead's thematic keyword. Metadata for an image is assigned by the user in the interface and consists of the textual description, the thematic bead keyword and the destination bead for the image. To provide flexibility in the interface there is a scratch space for holding images not yet placed in a bead container. A user can also develop a thematic keyword bank, a scrolling list of keywords that can be dragged and dropped on a bead to tag it. Once a necklace configuration is built it can be downloaded to the necklace by selecting menu pulldown item that initiates the process of sending the images to the images and text to the necklace via the serial port. The desktop interface communicates with the entire strand of beads through a serial port connected to a "loader bead." The loader bead, the first bead in a necklace, sends commands to the strand of beads to read and write data to and from the desktop interface.

Users can save necklace configurations for future uploading and subsequent downloading to the necklace.



Original User Interface Design

4.2 System Diagram



System Diagram showing a Story Bead necklace connected to the Desktop Interface.

4.3 Concept

4.3.1 Description

Story Beads was originally conceived as a wearable, artistic tool for visual story creation, a tool that would allow the collection of a large database of images and text a distributed storytelling engine capable of selecting different stories from the database. The wearable would also be capable of recording images with a small camera and displaying them on a mini-display.

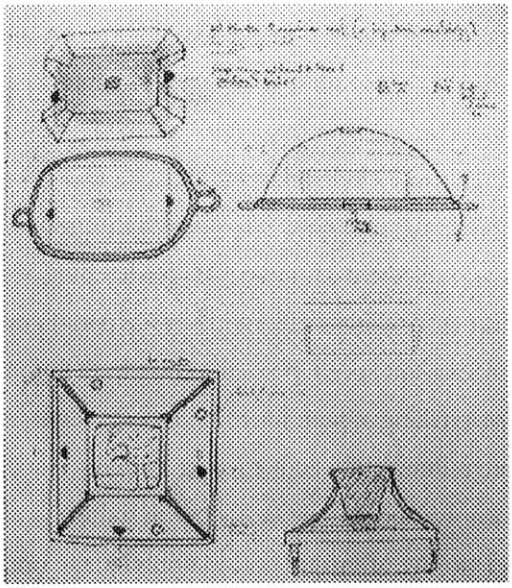
It was driven by a few different research spaces, related to storytelling, that I wanted to develop. I had been working on Dream Machine for the year prior and was particularly interested in expanding its messaging component to include images. As a storyteller, I was also interested in the idea of distributed story engines, where the individual story pieces not only contain associations by metadata about their possible use in the system but also contain behaviors that would influence the story playout. In my storytelling, I use a set of images to catalyze story performance. The images are collected around a certain theme. From the collection I create a set of narrative constraints that determine how I can sequence images, subsequently influencing the story playout. For example, in a story about a long journey to another world I might use the constraint of "two main characters must not meet until the last story fragment" or "the story must be evenly divided between scenes inside and outside" or, one of my favorites, "each abutted story fragment must contain a conflicting emotion." Another area of interest was the

ability of an object to digitally contain memories. With the miniaturization of computers and development of imbedded technologies it became clear that an object could contain digital stories. This would have applications beyond tracking the history of consumer products but for the art of storytelling as well.

The idea for Story Beads was sparked when I saw an exhibition of Flemish art of the past five hundred years at the Metropolitan Museum of Art in New York. The exhibit included two sets of rosary beads. The first was made of boxwood beads that could be opened to reveal miniature relief carvings of scenes from the Bible. The second set also had beads that contained images, in this instance of cast enameled gold.

The beads in the exhibition offered an analog version of a possible digital solution. Using beads as a form for collecting and messaging images offered strong connections to the concept of objects with embedded histories. The modularity of beads allowed for both physical and digital trading of images. Beads have strong cultural references to trading and storytelling. Beads can exist independently or as part of a necklace when strung together. They can be seen individually or as part of a network, a good paradigm for the distributed storytelling engine I wanted to develop.

4.3.2 Drawings



Early conceptual drawings for storage beads and the amulet bead.

4.4 Design Evolution

The concept of Story Beads went through design evolution to simplify the first implementation of the tool. Implementing all of the functionality described above was not possible in a small wearable at the time of concept generation. The design was influenced by two major factors - my work at Girls' Day at the Computer Clubhouse and collaboration with Kwin Kramer in a class about toy design.

At Girls' Day I worked with fourth grade girls on storytelling projects. These projects ranged from playing improvisational theater games to making short video stories to taking photographic collages. In these workshops I observed about how adolescent girls capture, augment and distribute digital images. During some storytelling work with a group of ten girls at the Computer Clubhouse Girls' Day, I observed the girls' relationships to images, stories and each other. The images that they photograph and collect are usually categorized by content and by audience. They were interested in taking images, trading them and printing them to give to someone. On presenting the image to their audience, usually a family member or friend, they would tell the story of the content of the image and the process they used to make it. The girls demanded physical control over the distribution of images. This particular user group is less interested in building a web site to broadcast their stories and more interested in building a collage or storybook that could be given to someone as an object. I decided to focus on the girls at the clubhouse as a primary audience for the project.

In a toy design, class Kwin Kramer agreed to collaborate on a storage bead prototype. He had been planning to build a smaller set of tiles, about bead size, and agreed to place a space on the footprint for storage of digital images. At that time it seemed possible to take Kramer's existing tile architecture, augmenting it to include images. The idea was to create a way for images to piggyback on the mobile code, the programs that hop via infrared from tile to tile. The bead system could be used for two different activities, one for learning about distributed networks and behaviors, the other for storytelling. The mobile code paradigm, combined with the limitations of infrared transmission speed, proved to be too slow to manage the command set needed for a distributed storytelling system based on mobile code. At this point a decision was made to switch to a different interaction and software design. The decision was made to use Kramer's hardware platform for the storage beads but to write a new operating system to allow for faster transmitting and storing of images and to optimize the operating system for the needs of the beads, transmitting and storing a lot of image data. The constraints of the hardware design effected the user interaction design. The system design became focused on trade, storage and display instead of a distributed story engine. The users would arrange, share and choose to

display images instead of a computational system. This simplified things considerably. Viewing StoryBeads as a toy for play, not solely as an artistic tool influenced the interaction design.

For the first prototype Story Beads would allow for two activities, trading and searching. Once a set of images was downloaded onto a set of beads, the user could display the image on the amulet viewing bead and trade the image to another necklace. The user could also design a software agent which would search through a series of necklaces, by being traded, and collect images fitting its search criteria. When the agent was traded back to the necklace of its origin, it would write the results of the search onto a designated bead.

4.5 First Prototype

At the time of testing the first prototype of Story Beads has the following capabilities. Images and keywords could be downloaded to the beads using the UI. The storage beads contained a string reference, the filename, to the actual images, which were stored on the desktop. The filenames were limited to nine characters. Each of the three descriptions associated with an image was limited to sixteen characters. The keyword assigned to a each bead was limited to 16 characters. Trading between storage beads was possible. Pressing the button on a bead when it was near another storage bead transmitted the current image. Pressing the button while not near another bead would increment the pointer to the next image on the bead. At the time of testing, the amulet bead was not functioning. Trading of images was from storage bead to storage bead, without a means to view the image until the beads involved in the trade were connected to the loader bead and their contents uploaded into the UI.[6]

5 Evaluations

5.1 Design

For the first test session two girls, ages ten and eleven, would use the system for a two-part test. In the first part, the beads would contain seeded content – still images from the Power Puff Girl cartoon episode entitled "Mr. Mojo's Rising" with keyword descriptions telling a sequential story of that episode. Each girl would get a set of four beads, each bead containing eight spaces for image storage for at total of thirty-two images. For the seeded content test, each girl's set of four beads would contain eight still-images with accompanying text descriptions. The images would be in the sequential order in which they appeared in the cartoon. Each girl would have a distinct set of 20 sequential images from the story. They can view the story by lining the beads up with the desktop user interface (UI).

The girls could redescribe the images with their own text, rearrange the images by moving the order of the beads or moving images to different beads in the user interface. They could also delete images using the UI. When away from the user interface, the girls could trade images from bead to bead. Holding a storage bead up to another storage bead and pressing its button copies the current image from the originating bead to the receiving bead. During this process the green LEDs light up. If a receiving bead is full, the transmitting bead flashes red. If a bead button is pressed when out of proximity to another bead the bead LED flashes blue and the image is moved to make the next image on the storage bead's stack the current image.
The girls could trade, repurpose and rearrange the seeded content. They could also add their own images to the story if they wanted by downloading them to the beads using UI.

In the second part of this test, the beads would function in the same way. A few days before using the Story Beads each girl would be given a digital camera to collect images she might want to put on the beads. For the Story Bead activity, the girls would each be given five empty beads. They can download any images and textual descriptions they like. The activities of trading, repuposing and rearranging would work the same way as in the seeded content activity.

The story forms and content of the original and resulting story would be recorded for evaluation. Each image would have a concatenated list of its description history, up to three descriptive phrases. It would also keep track of which images were native to a bead, downloaded originally from the user interface and which ones had been acquired through trading bead to bead.

After the story-building activity the users would be asked to comment on their experience of using the system and comments on how they imagine it working in the future. The testing would be videotaped to record the activity.

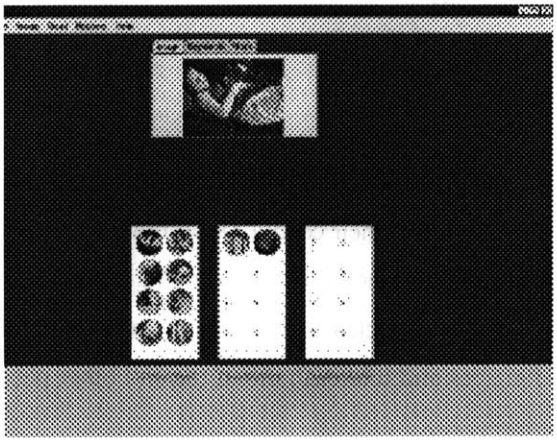
5.2 Results

When the two girls, Mara and Katherine arrived on the test day, only one had used her digital camera to record images.[6] We decided to go for a walk and take some pictures. While getting our jackets in my office the girls saw bags of glass beads that I had planned to give them after the testing. The bead bags went into the girls' pockets and we set out to gather some pictures. The girls took pictures of each other, people we encountered on the walk who they knew and pictures of nature. All of the photographs were shot in documentary style. There was no composing of subject or design of environment.

When we arrived back at the lab, the girls downloaded their pictures onto their individual PCs. Each girl had a PC configured to run the desktop application. The digital cameras assigned sequentially numbered filenames to their pictures. The girls renamed their picture files. If this step were not taken opening pictures in the Story Beads application would be random without any relevant association between the filename and its contents. Each girl opened the desktop application, then turned on each storage beads arranging a string of four next to the loader bead. They uploaded the existing contents of the empty beads, which appeared on the desktop as four rectangles each with eight spaces to place images. The girls opened their image files, placed them in the desktop application and wrote descriptions for each image. It took two hours for downloading pictures from the cameras, renaming them and putting them into the desktop application adding keyword descriptions. In the middle of the process Mara took a break and built a bracelet from her glass beads and some copper wire she found around the lab.

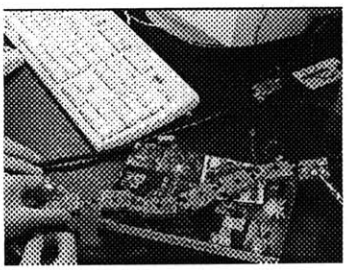
The girls were offered seeded content of sequenced stills from cartoon episodes if they wanted to start with those stories. Both girls preferred to use their own images. When one accidentally opened a cartoon still, she kept it, but singularly, not as part of a seeded sequence.

Mara completed her Story Bead necklace configuration first. She decided to put images on two out of four beads.

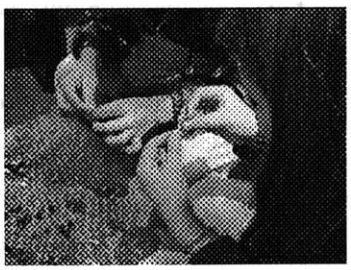


Katherine's original necklace configuration.

She downloaded the contents of her necklace configuration to the storage beads. Katherine had more images to annotate. Meanwhile, Mara took out her glass beads and began to sort them by type and color on the floor. Once Katherine was finished she began to download her configuration to her set of storage beads. The system crashed. Since the configuration was not saved, Katherine would have to remake a new configuration replacing and annotating all the that had been lost. While I was figuring out the source of the crash, Mara joined Katherine in bead sorting. They each sorted their glass beads. They traded a few beads, Katherine wanted mostly yellow, and began to collaborate building a necklace for Mara. While sitting on the floor they each had one side of the necklace string and were stringing beads, talking and, occasionally, asking my opinion on the next bead for the necklace. Katherine and Mara had never met before but were sharing stories about their families and summer activities while building the glass bead necklace.



Girls arranging a shared Story Bead necklace

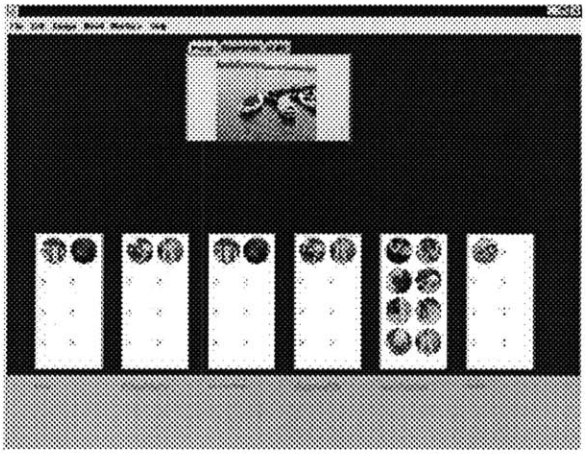


Girls building a glass bead necklace together

The Story Beads were back up and running. Katherine re-entered some of her previous images into the interface and left one bead blank. The images were uploaded successfully to the

necklace. During this test the beads were not in their plastic casings. I needed to tell the girls how the beads worked, mainly, how to press the button to trade images. They held beads up to other beads and traded images. When a bead was full of images, and no green flashed on an attempted trade, the girls tried to turn them around to fit more images through the infrared port not used in the previous trade.

After trading images, the girls moved to one desktop machine and strung all their beads together to look at the images, much like their collaboration building the glass bead necklace. They uploaded the images to the interface and viewed them. Two beads had files corrupted during the trade. They were taken off the necklace. The images were again loaded into the desktop. The girls saw the traded images and told each other, me and other people who happened to be in the room about their images.



Ending Necklace configuration. Co-Construction.

At the end of the activity, I asked the girls to describe their experience. They assured me it was fun and they just looked tired because they had to get up early to come to the lab. They liked taking the pictures and trading them with the beads. They also gave me some suggestions as to other ways that the beads might be fun. Mara thought the beads should not be expensive so people could afford to have a few of them. Mara also thought it would be fun to play games on the beads. The beads could get games from the desktop and would let you play the game while you walk around. Katherine thought that you could have a special bead that you could put things on, things no one else would see, even if they found the bead. It wouldn't be like the rest. She also thought the battery power ran out too fast. Beads should be smaller and have batteries that last for a long time, maybe making a bead charger for overnight. They both agreed that the beads should be prettier, more like the glass beads, in different colors and designs.

5.3 Comments

The glass beads were present during the Story Bead testing accidentally. Their presence and the girls' use of them showed a storytelling forum that was meditative, conversational, and engaging much like Winnicott's exploratory play space. The girls were facing each other involved in conversation about the activity of building and interjecting personal stories instead of communicating with a desktop machine, as in part of the Story Beads activity. They rejected the idea of a seeded content set entirely, and saw the beads as a way to organize and show their own images. The time and steps to get images on the system could be viewed as a disconnected tedious process that might be relieved by adding a gaming element to the UI.

The exchanges between the girls about the images in their stories were more descriptive. They told who was in the image, where it was taken or what it was about. Stories from Katherine about her dog were expressed while she was renaming the files but not in the UI. When she first opened the file she told me why her dog was named Orlando and how her sister had followed Orlando around for an entire day snapping photos. Orlando was moving so fast he was only half in the pictures, not one picture showed him sitting still. In the UI she used a more generic description "dog" or "face," in the case of a close up. It is much more a keywording system than one that encourages stands of descriptive text, which might be concatenated into a textual version of sequential story. The UI keywording activity could be designed to encourage the association of related images or the wrapping of stories around a single image. The girls thought was not necessarily important to have many pictures on a bead. They suggested one bead with lots of pictures or many beads with one each. Their critique was more object focused than story focused.

6 Conclusions

When a new tool for storytelling is introduced it takes year for techniques, styles and conventions of use to develop. The Lumeire Brothers made the first film using a Cinematograph in 1895. It lasted two minutes and was a continuous shot of a train pulling into the theater. People ran, not being used to seeing trains moving toward them indoors. In 2000, we have many genres of film, such as film noir, Hong Kong action films, and Dogme '97, of which have their own conventions, some rules, for building stories using images.[7] Story Beads, as part of a Distributed Storytelling technology, is a new tool. The users will become more knowledgeable in their construction techniques, physical and cognitive, as the medium is exposed to the public and as authors use the tool imaginatively as they face the constraints and opportunities of the medium.

6.1 Story Beads

The Story Beads were successful in that story fragments could be organized into collections and images described. It was clear from the first user testing that images were not sequenced into a story sujet. Individual images were traded and described in oral stories, one image to one story or piece of story. A strength of the system is its ability to allow both personal and co-construction of story. Users can build their own stories, contribute to another user's stories or participate in a co-authored story. The system is at the beginning stages of what would be needed to enact the story in the extended example. It does show that the process of transacting images to tell stories can be mobile and distributed. The tool encouraged sharing and construction. The redescription of story content using text was not a primary activity as it was imagined when the system was designed. The Story Beads do encourage repurposing of content by physical manipulation, stringing and trading physical beads, by digital repurposing as images are traded to a new author and by the redescription of content as images acquire description histories over time.

6.2 Transactional Storytelling

The beads were successful in allowing content to be shared, and stories to be built by repurposing in some scenarios. *Transactional Storytelling* may be better defined after seeing stories evolve in time after a significant content base is built by a community of users. Emergent rules for play could become a more important part of the negotiation process when trading images. The movement of images over time in the system might show a set of images always appearing in sequence or always traded when the evolving *Distributed Story* is in a particular state. Images

in the system could have fluctuating narrative value, just as objects classified by Csikszentmihalyi have fluctuating energies.

6.3 Future Work

Further user testing of Story Beads will show the story construction that the beads promote, Transactional Storytelling and other storytelling activities. Testing over time will also show the discovery of conventions of storytelling that are specific to the Story Beads as a tool and container for stories. Story Beads is likely to adopt some conventions and tools from the different story containers discussed in this thesis, cinema and oral storytelling.

The storytelling activity can be extended in few ways. I would like to build another version of the beads with scaled back storage capacity, yet room for the distributed storytelling engine as described in the Design concept section of this thesis. This would mean relieving the system of the intense computational load of shipping image data from memory to storage and from bead to bead so as to free up the processor for managing the storytelling algorithms. Image data could be stored as a referencing filename instead of the actual image and the users could connect and view their stories using a web browser connected to a central server which would hold all users' images. Another option for gathering images would be delivery of an image to projection screens in an architectural space.

Another approach would be to increase mobility, meaning freedom from a desktop machine and the ability to construct stories while moving through the world. This would involve implementing another mode of communication for the beads, using a short-range wireless connection, instead of the nearest neighbor infrared interaction. Recording beads could also be added to the system to allow pictures to be taken, and annotated, within the system. This would integrate the activity of collecting stories into the actual system.

Aesthetically, as suggested by the girls in the test group, the beads could be more colorful. The plastic casings can be dyed or sandblasted to create effects on individual beads. Another option is finding ways to cast the beads directly into acrylic instead of in a resin case. This would only be feasible if the batteries did not need to be replaced by opening the bead cases, as is the case now.

Story Beads will have more robust system with a functional amulet bead. This will have an impact on the ability to have finer control over the trading process and encourage oral storytelling during the trade of images. There are practical ways the system can be improved by

optimizing battery power, perhaps building a charging device, and general condensing of the form into a smaller, lighter bead.

To further observe and define Transactional Storytelling other systems that promote the art of storytelling through a trading activity will be built to observe the story forms and conventions they encourage and to expand the spaces for expression in Distributed Storytelling.

Footnotes

1. This story fabula is from the folktale "The Skeleton Woman," an Inuit tale of a woman who, after living under the sea for years, is caught in a fisherman's line and brought back to life on the land. The story is recounted in Estes' book "Women Who Run With the Wolves" as an archetypal tale of the Life/Death/Life cycle (Estes, 1995).

2. In E.M. Forster regards causality as a necessary element of narrative which distinguishes it from story. "A plot is a narrative of events, the emphasis falling on causality. 'The king died; the queen died' is a story. 'The king died, and then the queen died of grief' is a plot. The sequence is preserved, but the sense of causality overshadows it." (Forster, 1927).

3. Jerome Bruner uses this example by Mills to illustrate how our mind constructs worlds. Those worlds are incorporated into the larger culture. We each have our own reality, individually and collectively. Stories are part of that reality.

4. Here is Alfred Hitchcock's explanation of the power of montage. "There are two primary uses of cutting or montage in film: montage to create ideas--and montage to create violence and emotions. For example, in *Rear Window,* where Jimmy Stewart is thrown out of the window in the end, I just photographed that with feet, legs, arms, heads. Completely montage. I also photographed it from a distance, the complete action. There was no comparison between the two. There never is." (Bogdanovich, 1963).

5. The first implementation of Story Beads is related to a project called Triangles, developed by Margaret Orth, Matt Gorbet and Hiroshi Ishi of the MIT Media Lab. The triangles are a construction kit for building stories or songs using an interlocking system of computationally enhanced triangles to associate images. (Gorbet et al. 1998)

6. Pseudonyms have been used in the account of user testing.

7. Dogme '97 is a manifesto for a cinema verite style of filmmaking written by Lars Von Trier a Danish filmmaker as a reaction to big budget Hollywood films. The producers and directors of a Dogme '97 film agree to a "vow of chastity," a rule set for production. The vow includes rules such as the camera must be handheld, no artificial lighting can be used and the directors and producers must remain anonymous.

Bibliography

Adams, A. (1999). *Ansel Adams: An Autobiography.* New York: New York Graphics Society.

Berger, J. (1972). Ways of Seeing. London: British Broadcasting Corporation.

Bogdanovich.,P. (1963). The Cinema of Alfred Hitchcock. New York: Museum of Modern Art.

Borovoy, R., Martin, F., Vemuri, S., Resnick, M., Silverman, B., & Hancock, C. (1998). Meme tags and Community mirrors: Moving from conferences to collaboration. Proceedings of the ACM 1998 Conference on Computer Supported Cooperative Work., p 159, New York: Assciation for Computing Machinery.

Bruner, J. (1986). *Actual Minds, Possible Worlds.* Cambridge, Massachusetts: The MIT Press.

Cohen, J. (1991). *Barton Fink.* Twentieth Century Fox.

Csikszentmihalyi, M. (1981). *The Meaning of Things: Domestic Symbols of the Self.* Cambridge, England: Cambridge University Press.

Davenport, G. (1998). Encounters in a Dream World: A Work in Progress. MIT Media Lab.

Davenport, G., Agamanolis, S., Barry, B., Bradley, B., & Brooks, K. (2000). Synergistic storyscapes and constructionist cinematic sharing. *IBM Systems Journal,* Volume 39, numbers 3 & 4.

Dubin, L. (1987). *The History of Beads.* New York: Harry N. Abrams, Inc.

Estes, C. (1995). *Women Who Run With the Wolves: Myths and Stories of the Wild Woman Archetype.* New York: Random House.

Forster, E.M. (1927). *Aspects of the Novel.* New York: Harcourt, Brace & Company.

Garvey, C. (1977). *Play.* Cambridge, Massachusetts: Harvard University Press.

Gorbet, M., Orth, M., & Ishii, H. (1998). Triangles: Tangible Interface for the Manipulation and

Exploration of Digital Information Topography. *Proceedings of ACM CHI '98*, Los Angeles, ACM, April 1998.

Harel, I., & Papert, S. (1991). *Constructionism.* Norwood, New Jersey: Ablex Publishing Corp.

Hitchcock, A. (1954). *Rear Window.* Paramount Pictures.

Kermode, F. (1980). Secrets and Narrative Sequence. *Critical Inquiry, 7* (1) Chicago: The University of Chicago Press.

Kramer, K. (1998). Moveable objects, mobile code. MIT MS Thesis.

Kuleshov, L. (1974). *Kuleshov on Film.* Berkeley, California: University of California Press.

Kurosawa, R. (1985). *Ran.* Greenwich Film Production.

Laurel, B. (1998) An Interview with Brenda Laurel (Purple Moon), in *From Barbie to Mortal Combat: Gender and Computer Games.* Ed. Cassell, J., Jenkins, H., Cambridge, Massachusetts: MIT Press.

Livo, N., Rietz, S. (1986). *Storytelling: Process and Practice.* Englewood, Colorado: Libraries Unlimited.

Marker, C. (1992). *Le Jetee.* New York: Zone Books.

Mitchell, W. (1992). *The Reconfigured Eye.* Cambridge, Massachusetts: MIT Press.

McCaffery, S., Nichol, B.P. (1992). *Rational Geomancy: The Kids of the Book-Machine.* Vancouver: Talon Books.

McCloud, S.(1993). *Understanding Comics.* New York: Paradox Press.

Opie, I., P. (1969). *Children's Games in Street and Playground.* Oxford: The Clarendon Press.

Pipher, M. (1994). *Reviving Ophelia.* Toronto: Ballantine Books.

Resnick, M., & Rusk, N. (1996). The Computer Clubhouse: Preparing for Life in a Digital World, *IBM Systems Journal, 35* (3-4), pp.431-440.

Resnick, M., Martin, F., Berg, R., Borovoy, R., Colella, V., Kramer, K., Silverman, R. (1998). Digital Manipulatives: New Toys to Think With. *Proceedings of ACM CHI '98*, Los Angeles, ACM, 1998. p. 281-287.

Revenson, T., & Singer, D. (1978). *A Piaget Primer.* New York: Penguin Books.

Turkle, S., & Papert, S. (1992). Epistemological Pluarlism and the Revaluation of the Concrete. *Journal of Mathematical Behavior*, 11, 3-33.

Sontag, S. (1973). *On Photography.* Toronto: McGraw-Hill Ryerson, Ltd.

Webster, N. (1983) *Webster's New Universal Unabridged Dictionary.* New York: Simon and Schuster.

Winnicott, D.W. (1971). *Playing and Reality.* New York: Routledge.

Appendix

Historically, still and motion picture images have been displayed on displays that were bulky and more or less fixed to a specific local. Even in the digital domain, still and motion images have been stored for later recall on one or more digital hard drives. Story Beads makes image storage and display completely portable and even wearable. Story Beads consists of a series of storage beads and a display bead. Images are selected in a PC application and are loaded onto individual beads. Six images can be loaded onto individual beads. Beads can be tagged with metadata; images will be tagged with the same metadata once they are loaded onto a particular bead. Once images are loaded on the beads, the beads can be arranged as if in a necklace; the beads communicate via IR protocols. An image stored on one bead can be selected and passed from bead to bead until it arrives at the monitor bead and is displayed. By holding the image monitor up to another image monitor, the displayed image is able to "jump" across to another necklace.

Necklace

A Story Bead necklace has two types of beads. Storage beads store images and communicate with each other to move images around the necklace. Each necklace has one amulet bead that is used for displaying, trading or deleting images.

Storage Bead

Each storage bead has a core board, communication board and a power source. The core board provides the processing power for the bead using a Motorola 68HC912B32 microcontroller (MCU) running at 8MHz. The other components of the core board are a reset detector chip that monitors the battery power supply and a power switch. The communication board consists of a singular push button interface, two infrared communication ports and a 32K Serial Flash EEPROM for image storage. The infrared transmitter is an LED. When images are being passed from bead to bead the user knows the location of the image by the lit LED. The speed of infrared communication is 60 kilobits per second allowing for one 75 x 75 image file to be moved from one bead to another in 1 second. Each storage bead is powered by a 6 Volt silver oxide battery. The MCU draws 25 milliamps from this source. Battery life is six hours.

The Motorola 68HC912B32 was chosen as the MCU for its computational power and low power consumption. Kwin Kramer originally designed the hardware for the beads as modules in a distributed network that would support a mobile code paradigm. In that case the 68HC912B32 ran a Java Virtual Machine. The adaptation of the bead hardware for the Story Bead project involved rewriting the system software as a knowledge based system instead of a

moblie code network because the JVM took up too much space [where?] that was needed for [what?] in the current system. The major specifications for the 68HC912B32 that this system uses are the following: 16-bit central processing unit, multiplexed bus, 32Kbyte Flash EEPROM , 768 Byte EEPROM, 1Kbyte RAM, 8-Channel Timer, Pulse-Width Modulator, Synchronous Serial Peripheral Interface (SPI), J1850 Byte Data Link Communication (BDLC) A complete and detailed specification can be found at Http://199.104.132.208/ProdCat/psp/0,1250,68HC912B32~M98637,00.html.

Storage beads are the destination for images downloaded to the necklace from the desktop application and traded images downloaded by the amulet from a different necklace. By pressing the push button on a storage bead the user sends one image, packet by packet, to the amulet bead to be displayed. The user can cycles through each of the four images on the EEPROM by pressing the push button. If a bead is full no other images can be stored unless an existing image is deleted.

Amulet Bead

Each amulet bead consists of a communication board, a display board, a core board, an optical viewer and a power supply. The communication board is the same as the storage bead communication board. The display board drives the optical viewer. The optical viewer is an LCD display capable of displaying 320x240 images. The display board consists of an Argon chip analog display driver, a Krypton chip digital display driver, 1 Megabit SRAM for a CLUT, and 4 Megabit SRAM for VRAM. The display board communicates with the core board MCU using the Serial Peripheral Interconnect (SPI). The core board is the same as the core board for the storage bead with a few modifications. A voltage converter has been to allow the MCU to connect to the 3.3 Volt logic of the display board. An extra 6-pin connector carries the SPI signals from the MCU to the display board. The core board also handles infrared transfer of images from necklace to necklace and has two additional pushbuttons for image deletion and annotation with keywords stored on the amulet's communication layer in the Serial EEPROM .

The amulet bead us used for viewing and trading images. When a storage bead is pressed the current image in its Serial EEPROM is sent to the amulet and displayed on the LCD. The amulet interface has three push buttons. One deletes an image, one sends an image to another necklace via the third infrared to another amulet. The third toggles the LCD screen back and forth between viewing an image and it's associated text. When the amulet receives a new image it is sent to a storage bead by holding down the push button on the destination bead.

Desktop Application

The desktop application is used for organizing images and downloading image files to the beads. In the graphical user interface the user can organize images by describing them and putting them into containers that represent individual beads. There are two ways to describe Story Bead images. Images can have textual descriptions attached to them and are also associated by the keyword of the bead that contains them. Each bead is given a thematic keyword. Thematic keywords are single words used to describe the contents of a bead. For example, a bead with a thematic keyword "flying" might contain pictures of bugs, birds and airplanes. When images are placed in a bead container they are tagged with that bead's thematic keyword. Metadata for an image is assigned by the user in the interface and consists of the textual description, the thematic bead keyword and the destination bead for the image. To provide flexibility in the interface there is a scratch space for holding images not yet placed in a bead container. A user can also develop a thematic keyword bank, a scrolling list of keywords that can be dragged and dropped on a bead to tag it. When the user chooses to download the images to the beads the images are converted from gif image files into a file format that can be displayed by the amulet LCD. The application converts each pixel into a hexadecimal value and creates a color look up table (CLUT) for each image. It then attaches the string of metadata to each image file. The application sends the information in 64byte packets out the serial port to the MCU evaluation board. The evaluation board is physically connected to the first of a series of beads by a ribbon cable connected to the core of a bead by one of its 6-pin connectors. The evaluation board relays the packet to the first bead. The first bead, the loader bead, is controlled by the PC application and provides communication between the PC and the chain of beads. As the information arrives at the loader bead it will pass along images meant for other destinations via infrared. Each time the user downloads a set of images to the necklace any pre-existing images are overwritten. Any session, a collection of images, at the desktop application can be saved on the PC for future downloading to the beads.

The main functions of the Desktop Application are reading from and writing to the storage beads. The NecklaceReader.class handles communication with the string of beads via the serial port to read exiting images for display in the user interface. This class sends a command to the loader bead. The loader bead sends its necklace configuration table to be contained in the instantiation of NeckalceReader for each user request to download images. The beadloader then polls each bead and requests that each bead, starting with bead0, send their images packet by packet to the interface via the loaderbead and the 68HC12 evaluation board. The NecklaceWriter class has the same execution as the NecklaceReader but in reverse.

The desktop application was written by Eric Gunther and is implemented using the Java 2.0 platform. Please see Story Beads GUI / Serial Port Code Overview for a detailed description of implementation by class.

Display

The amulet bead receives packets of image data through the ir receivers of its communication board and sends them to the MCU of its core board via the electrical connection between the boards. The MCU strips the header from each packet then transfers the data to the ARGON chip of the display board via the SPUI bus. The ARGON is responsible for sending the binary image data to VRAM and sends the CLUT, made of three look-up tables – red, green and blue - for each complete image to CLUTRAM. The ARGON then polls the VRAM for the 8- bits of digital data that represent one gray scale pixel. It then polls the CLUTRAM three times and gets three 8-bit values (is this right?), one for each color channel. It sends this information to the KRYPTON chip. The KRYPTON sets up the LCD by converting the signal from digital to analog. It converts each of the 8-bit values into voltages and timing signals that are sent to the LCD. The LCD works by pulsing a red, green then blue channel at a speed of 180 pulses per second. The KRYPTON first sends the gray scale for the red channel to the active matrix liquid crystal display then sends a pulse to activate the red flash of the backlight behind the grayscale image. It repeats the same procedure for the green and blue channels. Four pins on the KRYPTON chip manage the color brightness and black calibration of the image.

Motorola Corp provided the chipset that drives the LCD. The design of the LCD circuit board for StoryBeads by Dan McGuire was based on schematics from the Motorola Corp. The SPI code, for communication between the MCU and the Display Board, was written in C by Marc Knight. For detail see attached schematics and code.

Communication

Bead communication is designed in two layers– the physical layer and the logical layer. The physical layer is for low-level messaging and establishes the necklace as a network by assigning each bead an ID starting with the rightmost bead on the necklace. Bead assignment happens when connecting a string of beads to the desktop interface and when communication is initiated after 15 seconds of complete inactivity on the necklace. The physical layer establishes the necklace of beads as a string of numbers that the logical layer uses to relay messages between beads. The logical layer is for high-level messaging such as passing image packets between beads. The logical layer transmits data into 64 byte packets that can be transferred via infrared

and stored easily on the Serial EEPROM. 64 bytes is the largest amount of data that can be written into storage on the Serial EEPROM in one write cycle. The current system has an infrared communication rate of approximately 60Kbits per second.

This two layer communication protocol allows for optimized speed of image transfer and accounts for a reconfiguration of the physical components of the necklace (eg, rearranging the order of the beads).

For details such as packet structure and error checking please see attached IR code. IR Communication code was written by Dan McGuire and Error checking code was written by George Lee.

Serial EEPROM Storage

Each Storage Bead has a 32K Serial EEPROM for storing image data. The MCU communicates with the Serial EEPROM using an I2C serial bus. The system uses I2C bus protocol as the communication driver. Communication with Serial EEPROM is limited to 400Khz significantly lower than the 8Mhz of the MCU. The I2C driver uses the timer subsystem to synchronize data for transmission.The MCU of each storage bead contains a table representing the storage space available on its Serial EEPROM.

Dan McGuire wrote the I2C interface code. For details please see attached I2C Interface code.

For more information:

http://ic.www.media.mit.edu/StoryBeads/