

Soft Interfaces for Interactive Storytelling: Learning about Identity and Communication

by

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Abstract

There is a need for technological tools specifically designed to encourage self-reflection. Stories are a good medium for this. This thesis presents a new approach to interactive storytelling: SAGE (Storytelling Agent Generation Environment), a construction kit that enables children to create their own wise storytellers. The children interact with their creations through both telling and listening to stories, thus exploring their inner world.

In the SAGE environment, the storyteller is embodied in a programmable interactive stuffed animal—a soft interface—to encourage children's emotional engagement. In order to support children as designers, as well as users of the storytellers, a visual programming language was implemented. With it they designed and programmed: 1) the scripts that the storyteller says, 2) the conversational structure or flow of the interaction, 3) the body behaviors of the toy, and 4) the database of narratives from which the storyteller selects a story relevant to the user.

This thesis presents technical aspects of SAGE's design and implementation as well as empirical results from user studies and workshops. The results showed that children had a tendency to open up and share their personal stories with the soft interactive interface. SAGE supported exploration of identity issues in several ways. Storytellers were projections of children's fears, feelings, interests and role models; they allowed the presentation of "the self" to themselves as well as others. Through designing and testing the conversational structures of their characters, children observed breakdowns in the interaction. This process engaged them in the exploration of notions of communication. SAGE took advantage of children's knowledge about storytelling to introduce them to the world of computer programming.

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"Some are holy in deeds, and some are holy in thought."

Menahem Mendel of Kotsk

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0. Scenario

Tami comes home after school and has many stories to tell: she had a fight with her friend and she is overwhelmed by the amount of homework she has to do. Tami needs to express herself. Instead of writing in her diary, she grabs her interactive stuffed rabbit, turns it on by putting a big pink hat on its head and the conversation starts.

Tami talks and the toy moves its ears and shakes its body as she speaks. Suddenly Tami stops and the rabbit asks her a question regarding her concerns. Tami realizes that there is something else that is bothering her. The toy's feedback, in a non-judgmental style, enables Tami to tell her personal stories and engage in an emotional relationship with herself.

When Tami has nothing else to say, the rabbit tells her a fairy tale about a princess in a similar situation. But Tami doesn't like fairy tales. She takes off the pink hat and puts on a grandmother hat. She wants to listen to what her grandma, who lives far away, would tell her as comfort. Tami has a collection of hats that represent different storytellers, and she can download through them the corresponding repertoire of stories from an on-line database. Using SAGE, the construction kit software that comes with the toy, she can also create a character that represents herself and contribute her own stories to the database.

Tami's older sister, Maria, is not interested in using the toy for self-reflection, she wants to learn from and teach with it. So she hooks the rabbit to the computer and programs the needed changes in its conversational style as well as in its body behaviors. For example, she programs the toy to look at her while she is talking and she makes it talk with a Spanish accent. The pet tells stories about its homeland and asks questions regarding how it feels to be far away from home. Maria will take her programmed interactive rabbit to her Social Sciences class next time they study immigration.

1. Introduction

"Buscar por el placer de buscar, no por el de encontrar."

Jorge Luis Borges

1.1 Overview of Research

Computers are evocative objects that can enable a self-reflective discourse (Turkle, 1984).

However, there is a lack of computer tools and programming environments explicitly designed to impact on identity formation. SAGE (Storytelling Agent Generation Environment), a construction kit that allows children to create their own wise storytellers, was designed with this explicit goal and uses storytelling to achieve its purpose.

Stories are one of the many ways in which the self is presented to others and to ourselves. When people communicate they often do it through telling stories about their experiences and by finding personal relevance in other people's stories. In this thesis I call this narrative activity, used with explicit communicative goals, conversational personal storytelling. SAGE enables and enhances this type of storytelling, as well as provides a framework for children to design and program their own embodied interactive storytellers. This meta-level activity aims to support changes in the way children think about themselves, and about storytelling and communication.

In everyday life, conversational personal storytelling is a communicational experience in which storytelling is as important as story-listening. Computer environments can encourage people to share their personal stories if we can set the appropriate context. At the same time, by supporting children's design of their own meaningful storytelling projects, learning about the self and the worlds of narrative and technology is also possible.

The SAGE project focused on three research aspects:

- 1) Designing and implementing a programming language with an embedded communication model to support children's creation of their own meaningful interactive storytellers.
- 2) Conducting research with children using SAGE. This research focused on two aspects:
 - understanding children's interactions with previously designed storytellers and their interface preferences,
 - exploring children's notions of communication, storytelling and self in the authoring experience of using SAGE to create their own interactive storytellers.
- 3) Embedding the storytelling agent into a physical toy with programmable verbal and non-verbal behaviors in order to enhance emotional awareness.

1.2 Contributions

This thesis lies at the intersection between technological tools for learning, narrative and self. The approach is interdisciplinary with contributions in three areas: theoretical, engineering and empirical.

- Theoretical: integration of social and cognitive theories within the field of Media Arts & Sciences in order to design computational environments well suited for children's interaction and learning.
- Engineering: design and implementation of the SAGE programming language and integration of the digital and the physical worlds (soft interfaces) focusing on applications oriented towards education, narrative and self-awareness.
- Empirical: conduct user studies as well as workshops with children in order to collect data that allows understanding of phenomena with both a quantitative and qualitative methodology.

With my work on SAGE, I wish to contribute to the spreading notion that computers, as "a second self" (Turkle, 1984), provoke us to think about our own inner world. I firmly believe that this is one of the computer's most powerful roles in the development of a better world: a place in which our children will be "sage" because they are more in touch with their own personal emotions, needs and desires as well as with the history and values of their families and cultures.

1.3 Reflective history of a personal motivation

When I was eight and people asked me "What do you want to be when you grow up ?" I used to surprise them by responding: "An ethologist. I want to study animal communication". I kept that idea for many years until school taught me to hate biology. So I dropped the word "animal" but kept "communication". Five years of studying Social Communication in Argentina went by, some of them working as a journalist, and a new word appeared: "computers". I came to the U.S., earned a Masters in Educational Technology, and then I joined the Media Lab.

In this thesis I am revisiting my early interest in animal communication, but from a different perspective and with a different goal. This time it is not the ambition to teach a chimpanzee how to talk. It is something else —more mundane but just as complex. It is the magic that happens when people communicate with each other and with their pets. Pets don't know anything about semantics, syntax and grammar, but can no doubt react by giving feedback and enabling empathic relationships. Leaving aside the question of the nature of pets' feelings, it is clear to me that what happens is that pets are a medium through which we communicate with ourselves. This kind of communication is the same evoked by personal diaries or journals, but in a more powerful way since the process of self-reflection is enhanced by feedback and emotional as well as physical engagement.

In the current work, I am interested in developing technology that enables self-reflective types of discourse in the same way that engaging with pets does. Following this interest, I decided to use in my research computationally augmented soft interfaces, such as toys, to evoke emotional awareness. The dream is to create a "good listener", in a narrow sense, that enables people to open up and explore their inner world thus becoming their own listeners to their own stories. My research evolved from playing with the idea of creating a soft technological tool that evokes self-reflection. The product became the first version of SAGE.

I created a Hasidic sage, Rabbi Moshe Grois, inspired by my great great grandfather. It is not surprising that the first storyteller I decided to build was a rabbi since many times I wished to become one. Constructing a simulated rabbi was for me a way of "cycling through" different aspects of myself (Turkle, 1996) and of experimenting with "what-if" questions that lead to identity explorations. As a first step to create my character, I recalled my past interactions with my rabbi teachers in Argentina as well as interviewed a couple of rabbis from the Boston area¹ who gave me interesting insights on the appropriate language used by American rabbis and on the dynamics of rabbinical counseling conversations. For example, they pointed out ways of turn-taking like "Nu" and traditional ways of avoiding answering precise questions.

From this anthropological experience that Clifford Geertz (1973) calls "being there", I developed a set of general rules for the computer implementation:

- Rabbis can relate stories to the values stated in the Ten Commandments.
- Rabbis first listen to personal stories without interrupting to ask questions.
- Rabbis listen and paraphrase in order to help the teller re-tell his or her story.
- Once the teller finishes, rabbis ask questions to find a relevant inspirational comforting story.
- Rabbis do not always need or want to understand the complex psycho-social context of the teller.
- Rabbis know that there is no perfect match between inspirational stories and personal stories.

They assume, however, that people will attribute meaning and interpret them according to their individual situations.

Based on these generic rules, I worked on a turn-taking algorithm. I also analyzed and indexed the Hasidic stories in the data-base. I selected fifty-four from different books, and I annotated which Ten Commandments or values described their message. During the annotation process I started to identify similar patterns among the stories. For example, the values "respect social justice" and the

¹Moshe Waldoks, an expert on Jewish storytelling, Rabbi Posner and Rabbi Joshua Plaut were very helpful and supportive for research on Jewish tradition. The scholar and translator Chris Cleary, for research on Taoism.

nouns "charity" and "brotherhood" were very frequent. At that time, I didn't realize that through the stories I was re-discovering the values of the Jewish tradition. Only when I created a second sage, a Taoist master, and annotated his stories, I found a different pattern; the commandments "respect to self-awareness" and the nouns "control" and "power" were the most salient.

My intuition said that the different patterns which emerged in the story annotation process reflected some of the values of each culture. So I decided to go back to the source books. On the one hand, I discovered that the version of the Tao I was using was written to guide the rulers of ancient China and to show them the path to "The Way". On the other hand, I connected the difficult historical times that gave birth to the Hasidic Movement in Eastern Europe to the message of love, pity and forgiveness that its tales convey. To annotate the stories in my database and recognize emergent patterns was one of the most powerful lessons of comparative religion I have ever had. By building my own meaningful sage storytellers, I could sense the power of the constructionist philosophy. And the experience was so powerful that I decided to devote my efforts to design a construction kit that would allow other people, especially children, to create their own meaningful storytellers and "listeners" for their personal stories.

1.4 Preview of this thesis

This thesis is structured in five main chapters. Chapter 2 addresses the context of the work and related research in the areas of:

- Interactive Storytelling: a situated approach for computational storytelling environments.
- Communication: narrative as a communication process of creating meaning.
- Psychology: the role of narrative in the construction of identity.
- Education: technological tools for learning.
- Interaction design: soft interfaces.

Chapter 3 describes the technical research aspects of the project:

- the design and implementation of the SAGE architecture.

- the design and implementation of the SAGE graphical programming language.
- the design and implementation of the integrated physical and digital soft interface.

Chapter 4 describes experiment protocols and methodology used in the empirical research aspects of the project and presents results of:

- user studies aimed at understanding children's interactions with the system and interface preferences.
- workshops aimed at understanding children's notions of self, storytelling and communication while designing and programming their own characters and communicational situations.

Chapter 5 presents analysis of learning stories showing the different types of experiences supported by the SAGE authoring experience. Chapter 6 draws conclusions and summarizes work accomplished. Chapter 7 addresses possible future directions in which problems with the actual system and the research methods are described and solutions are proposed. Finally, a bibliographic reference section and an appendix are presented.

2. Context of the work

"In fact, just as there is an art of story-telling, strictly codified through a thousand trials and errors, so there is also an art of listening, equally ancient and noble."

Primo Levi

The Monkey's Wrench

I organized the theoretical framework of this thesis in five areas : 1) A situated approach for interactive storytelling, 2) Narrative as a communication process, 3) The role of narrative in the construction of identity 4) Technological construction kits for learning, and 5) Soft interfaces to tell with. Every subsection will discuss research areas and then present SAGE's approach.

2.1 A situated approach for interactive storytelling

Today most of the research on computers and storytelling focuses on interactive games, mystery simulations, and theater metaphors (Laurel, 1993). Some work has been done on personal narratives² and family stories (Don, 1990). My early project "Rabbi", continued this line emphasizing the self-awareness possibilities of storytelling (Umaschi, 1996 a). Other work has used computation to assist production and viewing of narrative structure models. For example, "Agent Stories" (Brooks, 1997) is an environment for non-linear, cinematic story design and presentation that can be used by story writers.

Some work in Artificial Intelligence has approached narrative with the vision that computers should try to re-create the cognitive processes that people use to understand stories. In this area, research has been done on producing models of the world that contain particular knowledge organized around standard situations or cases (Schank & Riesbeck, 1981; Schank & Abelson, 1995). Other

²Several companies are recently focusing on new kinds of storytelling products. Mattel, Purple Moon and Girls Inc., for example, are trying to use narrative to reach the "girls" market.

research (Suchman, 1987), growing from anthropology and ethnomethodology instead of cognitive sciences, has proposed a theory of situated action as complementary to the traditional planning approach. The emphasis is not on mental processes but on social relations produced through the actions people take in the world.

The integration of both social and cognitive approaches was brought to the field of Artificial Intelligence by Winograd and Flores (1986) to understand how meaning involves a social as well as a mental dimension. Their work grows out of the philosophical tradition that includes hermeneutics, the study of interpretation and making meaning, and phenomenology, the study of the foundations of experience and action.

My research approaches stories as a cognitive as well as a socio-cultural process, conceiving communication as a way to take action in the world. In SAGE, a strong sense of situational context and a shared assumption about the socio-cultural role of the storyteller allow the user to find coherence between his/her personal stories and the comforting stories retrieved by the system.

In conversational storytelling systems, where user's stories are matched with stories stored in a database, work has been done in complex matching and indexing systems (Domeshek, 1992). However in my research, where the goal is to get the user to tell a personal story and to construct meaning out of a traditional story, the system doesn't need to be intelligent by itself, but rather can pretend it is by providing adequate feedback (Thórisson, 1996; Cassell et al., 1994).

Research has shown that the construction of emotionally believable characters with a limited field of interaction is required to maintain the suspension of disbelief of the user (Bates et al., 1995). The research presented in this thesis goes a step further within a genre defined by Murray (1991) as "a parodic interactive character whose computational rigidities model recognizably human types". SAGE offers a meta-level construction tool kit to build predictable characters. SAGE

borrowed from Eliza (Weizenbaum, 1976), Parry (Colby, 1975) and Julia (Mauldin, 1994) the notion of a simple conversational system but, first, extends the domain to the world of narrative; and second, allows storyteller construction as well as interaction. The SAGE construction kit allows children to create storytellers with strong stereotypical characteristics and well-defined domains that set up certain behavioral expectations. Given the appropriate socio-cultural context and situation, without limiting user's expressiveness, people's construction of meaningful relations and interpretations is possible.

2.2 Narrative as a communication process

I conceive of storytelling as a communication process in which meaning is constructed and negotiated between teller and listener. Jakobson's theory of communication involves the "encoding" of an idea into a signal by a sender, the transmission of this signal to a receiver, and the "decoding" of the signal into a message by the receiver (Polkinghorne, 1988). This theory belongs to the transmission model that Reddy calls "conduit metaphor" (1979) because it implies that language transfers human thoughts and feelings. However, communication is not only a process of transmitting information or symbols, but also one of making social commitments and interpretations (Winograd & Flores, 1986). Reddy calls this model of communication "the toolmakers paradigm" because people are actively constructing meaning.

Narrative is one of the primary forms by which human experience is made meaningful.

Polkinghorne (1988) describes it as "a scheme by means of which human beings give meaning to their experience of temporality and personal actions." My research focuses on a particular set of narratives—conversational stories—described by Polanyi (1989) as highly structured linguistic productions and by Miller et al. (1990) as face-to-face interactions in which self expression is accomplished by the recounting of personal experience.

Construction of narrative meaning happens in a communication process that includes a message, in this case an unfolding personal story, as well as a speaker and a listener and their social conditions of production and reception (Verón, 1987). The unit of analysis is not information but human action and interaction through language and non-verbal behavior. This unit is not produced in the heads of the conversants, but in the social relationship that they establish in a given situation and context (Bateson, 1972).

This view requires a shift from understanding language as description to understanding language as action which roots can be found in speech act theory (Austin, 1962) as well as in the study of communicative actions. Every communicative action constitutes an act of constructing meaning through interpretation, using semiotic and discourse devices (Wertsch, 1991). Meaning is fundamentally social and can't be reduced to isolated individuals. Although creation of meaning is a cognitive process, it needs to be produced and understood in a cultural, historical and institutional context. SAGE addresses these issues by providing a construction kit to design embodied interactive characters and their context.

2.3 The role of narrative in the construction of identity

Learning about the self and the inner world is not an easy task and there is a lack of technology especially designed to support this process. In order to construct our sense of self we use narrative structure to give coherence to life in an unfolding and developing story. Narrative is the primary form through which we understand and give meaning to our experiences (Polkinghorne, 1988). At the individual level, we have a narration of our own lives which enables us to construe our role in the world. At the cultural level, narrative gives cohesion to shared beliefs and transmit values.

Each culture or community has its repertoire of inspirational stories or "literature of the spirit" that serves similar pedagogical functions as myths (Campbell, 1988). They indirectly transmit how to live a good life and are not intended to match perfectly the listeners' situations; time, characters,

historical period and plot may vary. It is believed that in the very act of finding relevance the listener will find answers for his/her own situation. The power of this kind of storytelling lies in enabling the listeners to learn more about themselves by constructing personal meaning and interpretation.

Narrative seems to serve at least three vital functions:

1) A cognitive function: personal stories are fundamental constituents of human memory, and new experiences are interpreted in terms of old stories (Schank & Abelson, 1995). Bruner (1986) distinguishes two modes of thought that provide distinctive ways of ordering experience: the paradigmatic or logico-scientific and the narrative.

2) A social function: conversational personal stories have an important role in the social construction of the self from early childhood (Miller, 1990) and in the creation of coherent life stories (Linde, 1993).

3) An emotional function: storytelling has been used in very different forms of psychotherapy (Wigren, 1994). In fact, one view of psychotherapy is that it leads us to tell coherent life stories. The value of tales has been explored by Erickson in hypnotherapy (Rosen, 1982) and in fairy tales by Bettelheim (1976).

SAGE explicitly aims to enable children to explore their inner world, developing a better sense of who they are and a set of values for constructing their role in the world. By designing and interacting with their own meaningful characters they express their voice (Cassell, 1997) as well as their identity. Through this verbal-play experience of storytelling, children can find not only recreation but also self-cure (Erikson, 1950). To play is a function of the ego, an attempt to synchronize the bodily and the social processes of growing up with the self. SAGE was specially conceived to help children "play out" what is happening in their lives by telling and listening to stories .

The psychotherapist Carl Rogers (1961) defined the act of listening as one of the basis for a helping relationship. He described this type of relationship as one in which the person can discover within him or herself the possibility of growth. Rogers talked about helping relationships in which the therapist is involved, however, we can extend this notion to the use of tools that allow the person to become his or her own listener. Personal diaries and journals are good examples as well as computational environments such as SAGE. My research aims to contribute to this area of self-awareness.

2.4 Technological construction kits for learning

Constructionism asserts that learners are likely to create new ideas when they are actively engaged in making external artifacts that they can reflect upon and share with others (Papert, 1980). In the light of this approach, my research focuses on building narratives and sage storytellers as "evocative objects" that invite reflection about identity and communication (Turkle, 1984, 1995).

Computational construction kits are tools that support children's design and construction of their own projects (Resnick et al, 1996). SAGE is a construction kit that includes the two types of connections required by constructionism: 1) personal connections: children can program their interactive embodied storytellers according to their own culture and interests, and 2) epistemological connections: SAGE encourages new ways of thinking about storytelling, communication and the self.

Extensive work has been done within the constructionism educational philosophy on creating tools to help children think in different ways about the sciences and mathematics (Harel & Papert, 1993). For example, microworlds such as Logo and Starlogo, an extension of Logo that allows parallel processing to create decentralized systems (Resnick, 1994), support direct manipulation as well as reflection about the programming process. Environments such as Boxer use two key principles: the spatial metaphor to "encourage people to interpret the organization of the

computational system in terms of spatial relationships" and naive realism as an extension of "what you see is what you get" (diSessa & Abelson, 1986). Visual Agent Talk (Repenning, 1996), an end user programming environment with a low threshold and a high ceiling, looks for a balance between ease-of-use and expressiveness. However, little work has yet been done on how to design technological tools that help children learn about themselves, cultural values (Hooper, 1996), narrative and language (Bruckman, 1994).

SAGE Storytellers contributes by providing an authoring environment and programming language where children can create their own interactive storytellers. When children look at their own culture and role models in order to detect communication patterns and characteristic vocabulary in conversations, they behave as young ethnographers in search of data (Geertz, 1973). When children build embodied storytellers and their underlying turn-taking rules and body movements, they behave as designers as well as programmers. By creating their own simulated characters they become explicitly aware of the structure of the conversation by anticipating breakdowns in their turn-taking design—or finite state machines. Programming, in this case, is a vehicle for the transformation of ways of thinking about the self and communication as well as for constructing knowledge about technology.

2.5 Soft interfaces to tell with

The discipline of human-computer interaction is moving from a mouse and keyboard metaphor to one of ubiquitous computing and tangible media (Ishii & Ullmer, 1997). The challenge is to integrate the digital with the physical world, and research has been done looking specifically at computationally-augmented toys for storytelling (Glos & Umaschi, 1997). Children establish intimate relationships with their toys. The natural tendency to communicate at a deep level with soft

objects can be leveraged by adding computational abilities so toys can give feedback³ (Umaschi, 1997).

The psychologist Winnicott (1971) introduced the term "transitional object" to refer to the first "not-me" infant's object. As time goes by, the first infant's "transitional object" becomes one of many toys in the child's life. However, not all the objects have the same value: the favorite toy, as described by Winnicott "must seem to the infant to give warmth, or to move, or to have texture, or to do something that seems to show it has vitality or reality of its own."

Following this line and in order to support emotional engagement, SAGE embeds the storyteller in a programmable interactive stuffed animal. Children can decide the toy's communicative behaviors as well as the different hats or personalities that it might have. The idea of an interface that emphasizes emotional as well as cognitive engagement was explored by Laurel (1993) in her dramatic theory of human-computer activity. My research extends this work to the domain of conversational personal stories using a soft interface.

Roland Barthes (1972) suggests that the meaning and the use of an object, such as a toy, is a semiotic problem and not a factual one. His claim is that objects lose their historical and ideological qualities and are "naturalized" by the principle of myth that transforms history into nature. The meaning of objects lies not only in what they are made of, but on the metaphors that they evoke. This quote of the "The Velveteen Rabbit", by Margery Williams, makes the point: "*What is real?*" *asked the Rabbit one day... 'Does it mean having things that buzz inside you and a stick-out handle?' 'Real isn't how you are made', said the Skin Horse. 'It's a thing that happens to you.*

³In this line, Microsoft has developed a new interactive toy called Barney. The toy communicates with the PC wirelessly and reacts to CD-ROM games that the child plays. However, the questions are: what do we understand by feedback, an already programmed repetitive motion, or a behavior that responds to user's actions ? and, how long would a child play with a toy that, at the beginning, seems alive and therefore creates higher expectations, and later, can become repetitive and boring ? My answer is that we need to create environments where children can be the designers of their own toys and toy feedback abilities, as well as the users.

When a child loves you for a long, long time, not just to play with, but really loves you, then you become real."

The metaphorical properties of objects are essential elements in exploring the world of narrative. If much of our common cultural knowledge is structured as metaphoric models (Lakoff & Johnson, 1980), we need to understand what kinds of metaphors are evoked by the objects around us. In this direction Dr. LegoHead (Borovoy, 1996), a computational construction environment, allows children to build creatures out of high level Lego parts such as eyes and mouths. However, the physical constraints of the Lego bricks, while well suited to building engineering and boy-like constructions, can be very limiting in other domains.

Different materials have different characteristics and use different senses and engagement levels. Druin (1987) started to explore this by building a gigantic furry animal called Noobie, an alternative to the traditional computer terminal. For example, squeezing parts of Noobie, children could observe the selected animal part on the screen in Noobie's stomach. Druin's purpose was to create computer environments that do not deprive our senses and that emphasize emotional contact. Similar goals are achieved by SAGE.

3. SAGE Storytellers: technical implementation

"What is important is that people using the system recognize two critical things. First, they are using the structures of their natural language to interact with a system that does not understand the language but is able to manipulate some of those structures. Second, the responses reflect a particular representation that was created by some person or group of people."

Terry Winograd & Fernando Flores

The LISP-based SAGE architecture⁴ has three main components shown in figure 1:

- the SAGE computation module: in charge of parsing the user's story, expanding the keywords through WordNet and performing the match with the comforting story in the database.
- the SAGE programming language: used by children to design their own interactive characters.
- the SAGE interface: the interactive toy (output) and the computer screen and keyboard (input).

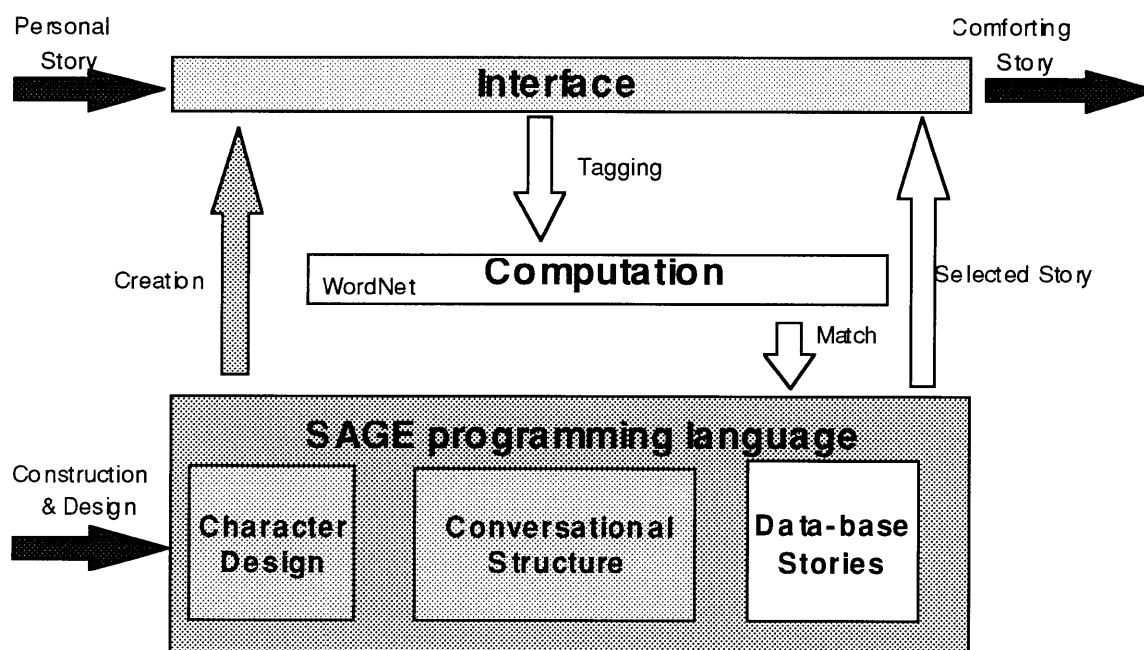


Figure 1: The three components of SAGE: interface, computation module and programming language. The user can engage with the system at the interacting level by telling a personal story and listening to a comforting story, or at the authoring level by using the programming language to design his/her own storytelling characters.

⁴For a detailed explanation of the LISP code, see the SAGE documentation (programmer and user manual) available as a Technical Report from the Gesture & Narrative Language Group at the MIT Media Laboratory.

The SAGE computation module is in charge of the low level computation such as parsing the user's story, expanding the user's keywords with related concepts through WordNet, searching through the database of stories and retrieving the best story match. This level is not directly accessed by the user (see sub-section 3.1).

The SAGE visually-based programming language (see sub-section 3.2) allows children to create their own embodied interactive storytellers by designing and programming:

- the conversational flow and turn-taking rules,
- the script for the storyteller ,
- the body behaviors of the interactive programmable toy, and
- the database of comforting stories.

The SAGE interface is the layer through which a user communicates with the system. The output device is composed by an interactive stuffed animal with programmable body behaviors and the computer screen with a graphical representation of a storyteller and his/her talking balloon and speech/sound output. The input device is the keyboard (see sub-section 3.3).

3.1 The SAGE computation module

The computation module is composed of three parts: a tagger, WordNet and a matcher. SAGE parses user discourse through a part-of-speech tagger⁵ that uses context to assign parts of speech to words. It checks for personal pronouns in order to determine if the user is telling a personal story and for keywords. In order to match the user's personal story with a comforting story in the database, in each turn of the user, it assigns higher scores to the most repeated nouns and verbs and expands them with related concepts found through WordNet (Miller et al.,1993; Sack, 1995). For a simplified graphical representation of this process see figure 2.

⁵In the current SAGE version we use the Xerox Parc parser available through anonymous ftp.

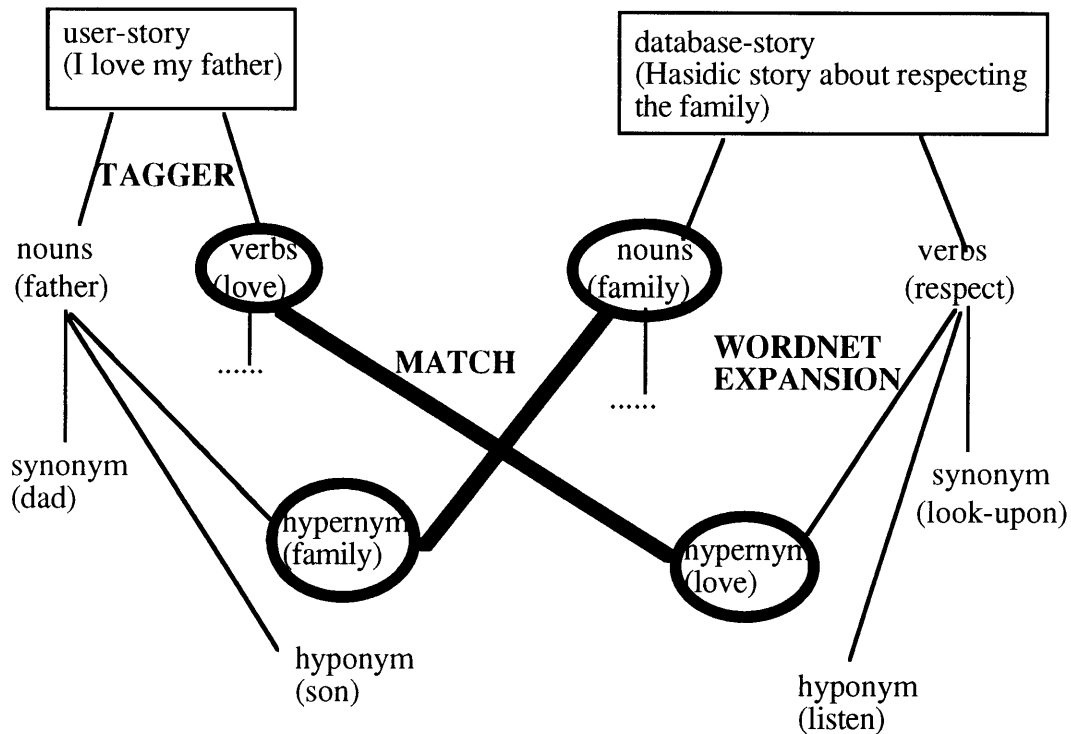


Fig. 2 shows how the tagger, the WordNet expansions and the matcher works.

WordNet is a hierarchical semantic lexical reference system in which nouns, verbs and adjectives are organized into sets of synonyms each representing a concept. The synonym sets are linked by semantic relations. SAGE uses the following relations: synonymy (symmetric), antonymy (symmetric), hyponymy (hierarchical, supra-name) and hypernymy (hierarchical, super-name). WordNet offers a list of alternatives that correspond to the requested semantic relation, but it doesn't resolve polysemy, the multiplicity of meaning, one of the main problems of dealing with natural language⁶.

The matching algorithm attempts to maximize the similarity between the user input and the story in the data-base. Each comforting story stored in the database is indexed with three descriptors⁷,

⁶Prof. Ken Haase, head of the Machine Understanding Group at the Media Lab, and his students have been exploring these issues for a long time.

⁷The decision to annotate the stories by hand instead of automatically, responds to the educational goal of SAGE. To annotate a story requires people to think about the point being made by that story. Moreover, automatic computational story understanding is a very difficult problem.

"Story Values", "Nouns" and "Verbs" (see Fig. 3). Those descriptors are expanded by WordNet with related concepts such as synonyms, antonyms, hyponyms and hypernyms. For matching purposes, the descriptors and their expansions are weighted as follows: the nouns and verbs descriptors and their synonyms found through WordNet get a score of 2, all other expansions get a score of 1, however story values and their expansions are scored 6 for synonyms and 3 for others. The descriptor "story values" is weighted more heavily because it sets up the story domain. Below is presented a matching example.

```
SAGE: Owen, I am Chuan-Tzu, the Taoist sage of the cyberspace who
seeks freedom from labeling things right or wrong. What is your age,
Owen ?
USER: 20
SAGE: I am 80 years older than you... I am older than the mountains
and the seas, while you, Owen are still young. What brings you to my
solitary place ?
USER: Well if you think there is nothing right or wrong, I don't see
how you can help me.
SAGE: I see, but you are not alone in your quest for the Way. Owen,
let me tell you... The Sage accumulates nothing. Having used what he
had for others, he has even more. Having given what he had to others,
what he has is even greater. Have you grasped the meaning ?
```

The Taoist story matched in the data-base was indexed under the Descriptors "justice" and "help". This is part of the run-time expansion done through WordNet in order to match a story from the database:

```
                user story with database story
    matched aid(4): SYNONYM of help (2) with SYNONYM of help (2)
    matched assist(1): HYPONYM of help (1) with HYPONYM of help (1)
    matched judge(6): HYPERNYM of think(1) with SYNONYM of justice(6)
    matched propose (2): SYNONYM of think (2) with HYPERNYM of offer (1)
```

User stories are parsed into verbs and nouns. These keywords undergo a similar expansion and scoring as the descriptors of the comforting stories in the database described above. A matching story is found by ranking the stories in the database according to the number of matching descriptors, i.e. a descriptor found in both user story and comforting story in the database. Specifically, the rank of a story is equal to the sum of the products of the scores of each matching

matching pair of descriptors. The pseudo-code to calculate the rank of comforting story X in the data-base according to user story Y is as follows:

```
rank = 0
for each descriptor d of X
  if d is in descriptors of Y
    rank = rank + X_score(d) * Y_score(d)
```

The use of WordNet to expand user stories to match a comforting story from the database is not always enough to help users find their own relevant connections between stories. WordNet expansions sometimes take a very long time and yet do not always include the everyday vocabulary that people use to tell their stories. In order to address this issue, a customized database of concepts was implemented. This small database is composed of terms that children learn at an early age and are commonly used. This is one feature of the research done on basic-level categories (Rosch & Mervis, 1975). This customized database complements the super and subordinate levels set by WordNet and the SAGE computation module access it as it accesses WordNet⁸.

In both the Taoist master and the Hassidic rabbi examples, the story values were selected according to one of the universal values stated in the Ten Commandments. In the Bible, the Ten Commandments are written in a negative form. However, when inverted to a positive form, they seem to refer to respect for different life domains: God or a superior entity, self-awareness, traditions, life cycles, family members, nature, commitment, things or objects, social justice and people. The following Hasidic story was annotated in the database with this set of descriptors in the form of a LISP list:

```
(score(story-value (justice others)) (noun (prayer)) (verb (being-equal
practice)) (file (hstory-11)))
```

⁸In the original SAGE design, children were supposed to be able to customize this vocabulary database. However, as the implementation of the visual language began, this feature was not further developed.

"A Jewish carriage driver came one day to see Reb Levi Yitzhak of Berditchev. The driver was facing a religious problem and needed sage advice. "Rabbi," the man began, "I want to be able to come to pray in the synagogue more often, so that I may be in the presence of the Almighty. Here is my problem. I am always so busy driving others around that I do not have the necessary time to pray correctly. Maybe I ought to change my profession." Reb Levi looked at the man and asked, "Are you fair in what you charge? Do you charge all people the same fare?" "Of course, Rabbi," the driver answered. "But what about the very poor? What do you do about them?" The driver said, simply, "I don't charge them at all." Reb Levi said to the driver, "My son, you are already in the presence of the Almighty. You just don't know it."

See section 4.1.2.2 for an evaluation of the story matching capabilities of SAGE.

3.2 The SAGE Programming Language

The SAGE programming language has an embedded communication model: turn-taking-based storytelling conversations. The programming language has a graphical user interface that allows children both to design storytellers to interact with and also to model different types of communicational and storytelling situations. The design of the authoring environment is based on the theoretical communication framework presented in the context of the work chapter.

The SAGE environment is composed by three main windows that can be chosen from a menu:

- Character's creation: users create different facts about the lives of the sage storyteller and its assistant, as well as load pictures of them (see figure 3).
- Conversational Structure window: users design the conversational flow (see figure 4).
- Database of stories: users can write or scan in comforting stories and record them with their own voice. They can also categorize or annotate the stories with story values, and nouns and verbs that they consider good descriptors of the main story points (see figure 6).

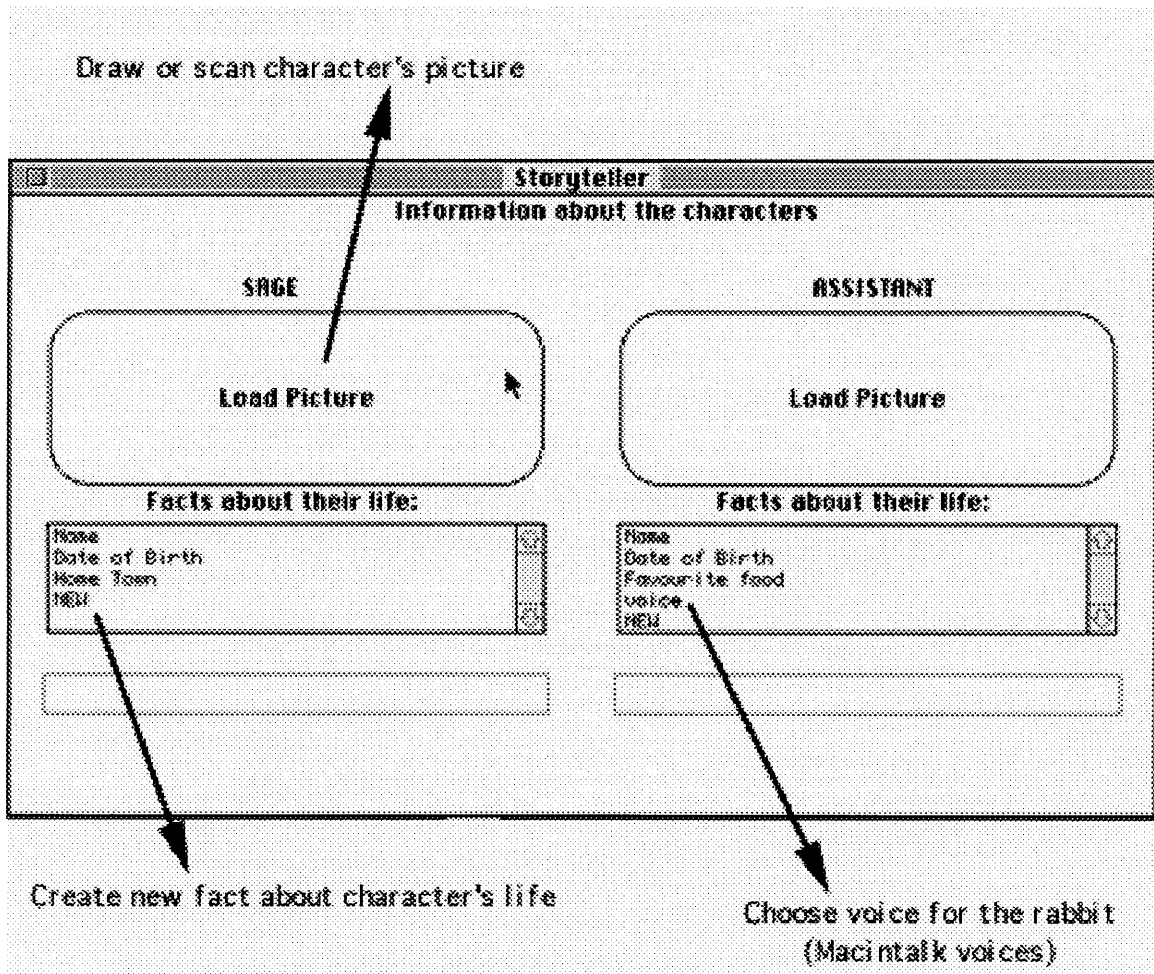


Figure 3: The character's creation window

The SAGE language has a palette with three sets of objects —turn-taking states, communicational actions and parts of conversation— that can be placed in the conversational structure window.

These objects are intended to model the conversational storytelling interaction (Fig. 4).

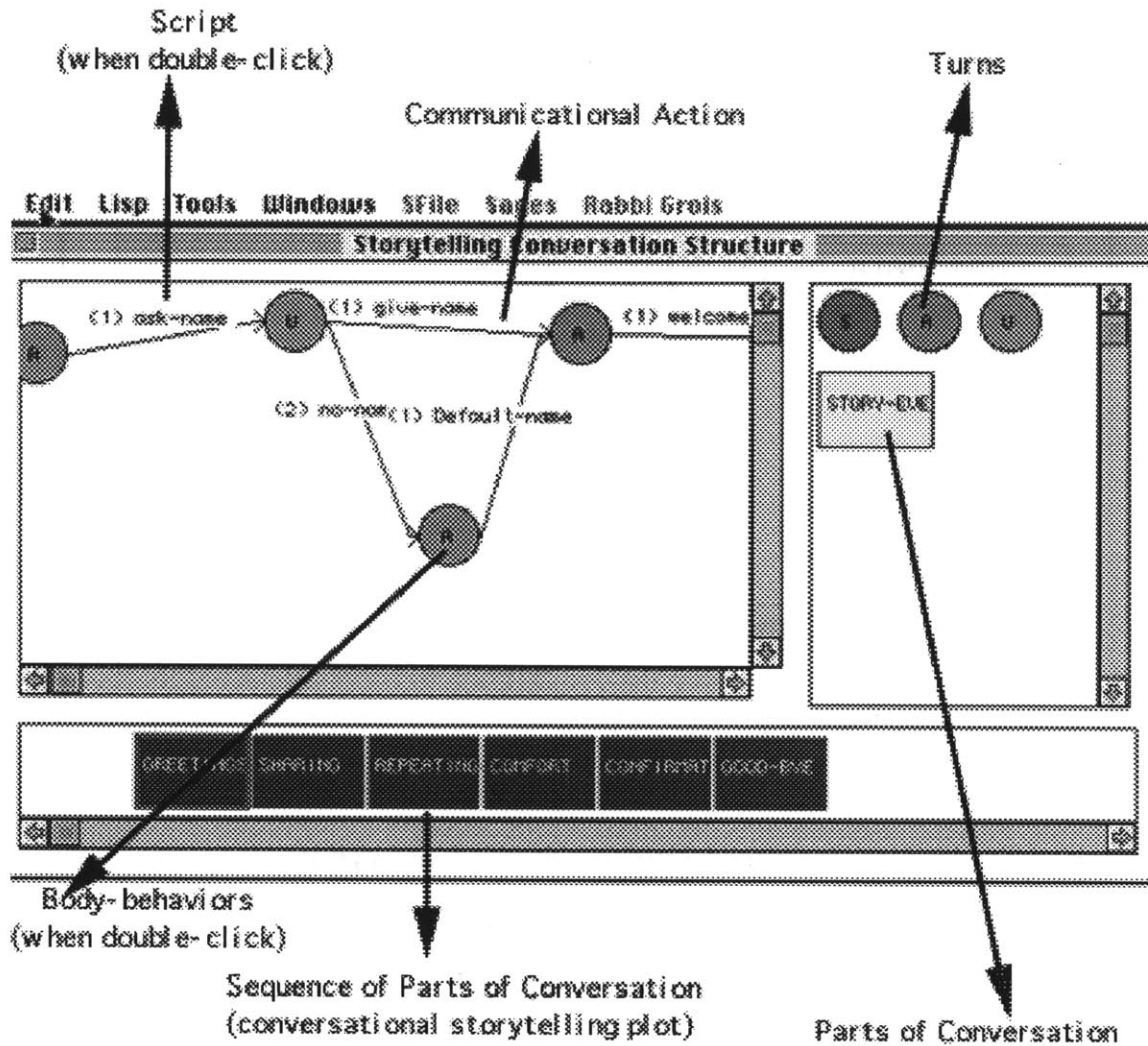


Figure 4: Programming language objects used to create the conversational flow.

The objects in the SAGE palette are:

1) Turn-Taking states that respond to the question "Who has the floor?":

- sage storyteller (S)
- assistant (A)
- user (U)

The states (S) and (A) have attributes or associated actions (puppet actions) that determine the sequence of body behaviors of the interactive toy in each turn, i.e. "ears up" to show attention (see figure 5).

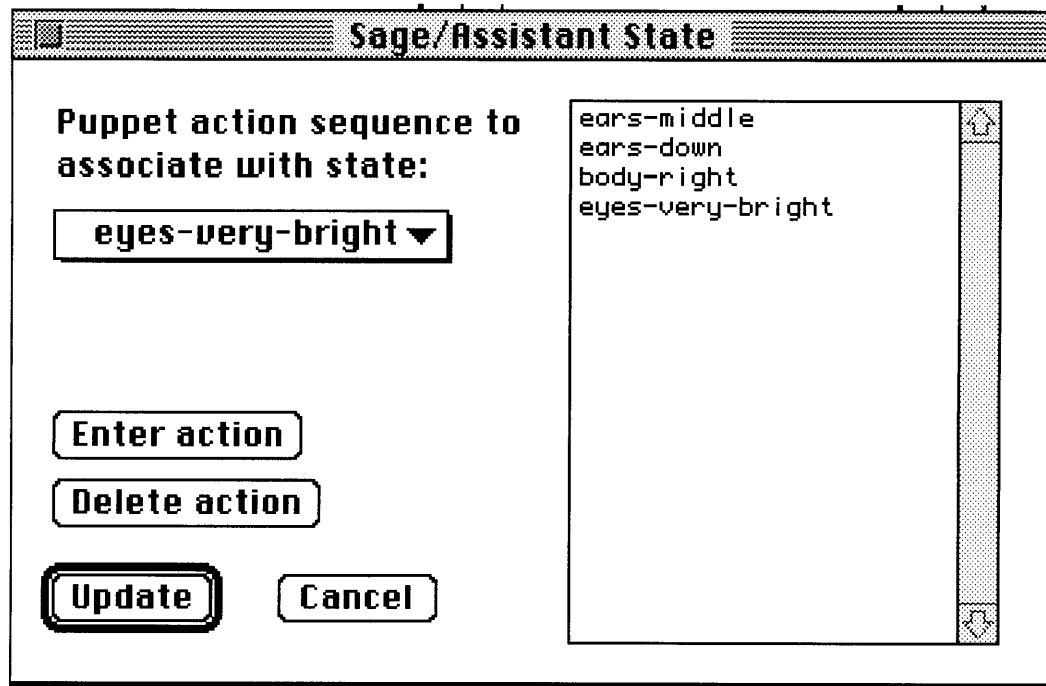


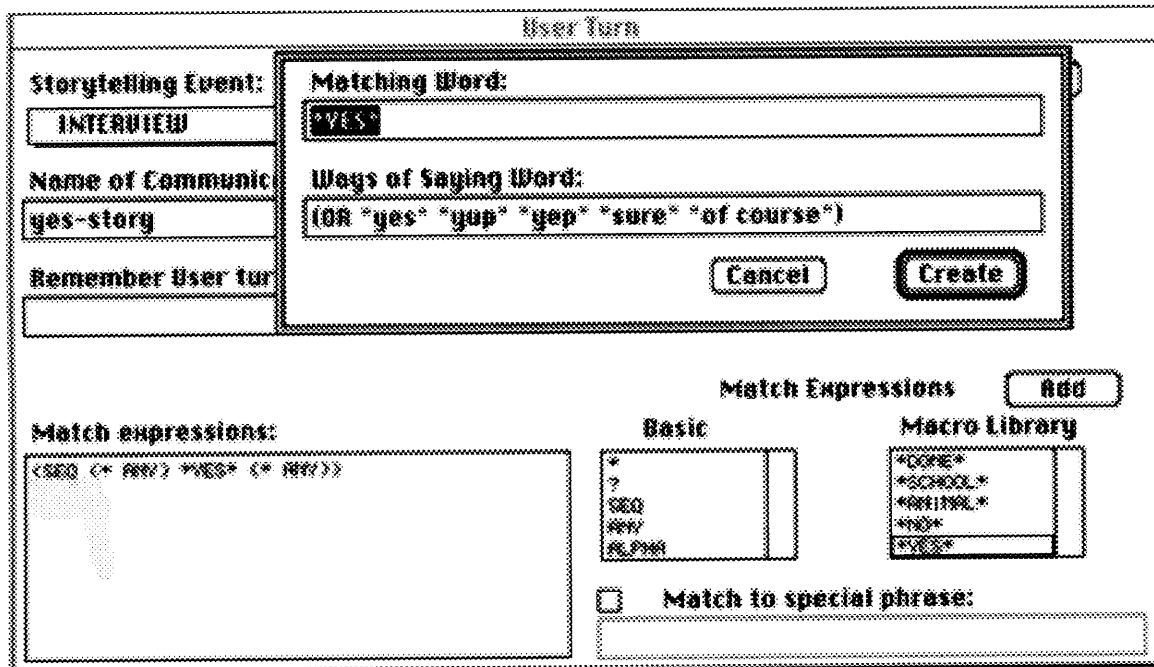
Figure 5 shows the window that pops up when the sage or assistant turns are double-clicked.

2) Communicational actions: these are the state transitions or arrows that convey conversational actions such as requesting, accepting, rejecting and negotiating. Communicational actions have scripts (or speech acts embodied in sentences) as attributes.

- requesting: (S) and (A) turn; ask for user input
- accepting and rejecting: (U) turn; requires matching user's input
- negotiating: (S) and (A) turn formed by a compound expression composed by either requesting and accepting or requesting and rejecting. These compound expressions open and close inner loops, or nested states, and require matching user's input.

3) Parts of conversation: meta-objects or meaningful parts of the interaction, such as introduction, personal telling, etc., composed by the combination of turns and communicational actions. These high-level or meta-objects are the more abstract parts of the conversation and create the conversational storytelling plot.

User input is recognized by a pattern-matching structure, set by the designer as a template in the communicational action coming from the user. A particular input string is said to match with the template if it fits the pattern described by that template. The match templates have a recursive syntax based on primitives, combining forms and iterating forms⁹. For example, to match any strings that contain the substring "yes", we can use: (seq (* any) "yes" (* any)). However there are many other ways of saying "yes" without actually using that word. To account for other affirmative responses, we created a match-macro command that can be edited according to user preferences. In the "yes" example, the match-macro looks like this:



Match-macros allow users to define custom match template forms giving flexibility to the system. The syntax isn't English-like but it is a first step towards getting novices to work with language. Further work needs to be done to implement more intuitive ways of analyzing user input.

⁹The syntax of match templates used by SAGE is a subset of the syntax of Prof. Szolovits's SMATCH pattern language.

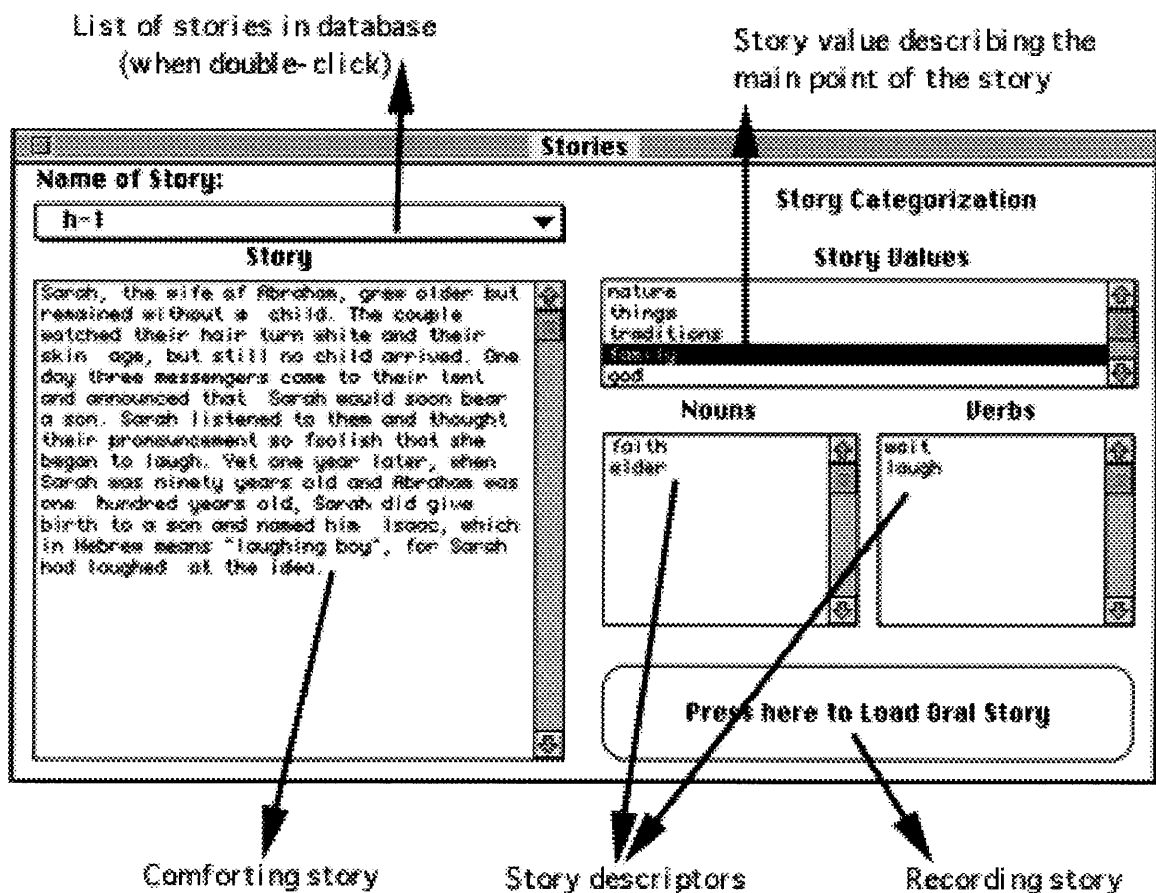


Figure 6: The database of comforting stories window

The decision to create the SAGE programming language was made based on the belief that programming is a tool that facilitates knowledge in other domains. While programming and designing their own storytellers, children learn how to define goals, pre-plan and represent communicational situations, categorize stories, make connections, test their ideas, reflect upon their mistakes and modify their initial ideas. These skills are useful in different life domains, not only in programming. For a good overview of different programming environments for children see (Begel, 1997).

The SAGE programming language has the following characteristics:

- Graphical user interface (GUI) : a standard graphical representation for children to easily create, manipulate and edit their conversational flows by clicking and dragging objects such as story events, turns and communicational actions off of a palette.
- Scaffolding: novice users can get started with their projects very quickly and later, after becoming expert users, be challenged to develop further understanding and complex productions.
- Availability of examples: children can always look at other children's storytellers and use parts of their code by "cutting", "pasting" or modifying it. SAGE is an open environment in which code is always accessible by users. Everything is an example for others to use.
- Ease of use: the GUI allows children to create conversational flows in the same way that they usually play pretend games, by planning "who" is going to say "what", and "when" (Cassell, 1997) while dragging objects to the conversational structure window off of a palette.
- Limited domain: the SAGE programming language only allows the user to create directed conversational storytelling situations.

3.3 The SAGE interface

SAGE is specifically designed to promote children's emotional as well as cognitive engagement. In order to achieve these goals I decided to use a soft interface: a programmable interactive stuffed animal that can give verbal and body feedback. Since the technology is not yet available to create a stand-alone interactive toy (the main obstacle is the lack of adequate speech recognition systems), I integrated the computer with a physical toy.

To overcome technical difficulties, such as having a separate input (computer) and output device (toy) I used narrative devices such as narrator's voice and point of view. For example, the interactive conversation happens with the toy, which is the assistant of the sage storyteller that lives on the computer screen. This character, with an internal microphone installed, can interactively

respond to the user through a speech synthesizer¹⁰. The assistant carries on the conversation and, at a certain point, calls on the sage storyteller to tell a comforting story. The storyteller is a character that lives in the computer. He or she is only in charge of telling the canned pre-recorded comforting stories from the database.

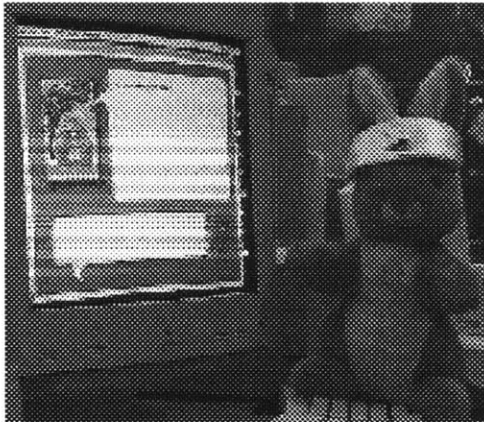


Figure 7: The interactive rabbit is the assistant of the Taoist storyteller displayed on the screen.

This distributed model is observed in traditional ways of counseling. For example, in the old Hassidic movement the rabbi had an assistant or disciple, the gabbi, who gathered information from the visitor (Schachter-Shalomi, 1991) and later called the rabbi to tell the relevant story or give the blessing. This

model can also be found in hospitals with doctors and nurses. The assistant helps to formalize the input that needs to be accessed by the rabbi, the doctor or the storyteller, as in SAGE. This method allowed me to create a more believable interaction by having a multi-party conversation between user, sage's assistant (toy) and sage storyteller (computer) (see Figure 7). This was needed due to the impossibility of pre-recording a response to every single user-input and therefore run-time speech syntheses was required. However, this technology is not good enough to engage the user to listen carefully to a story. Therefore, the stories were canned and pre-recorded by a human. Despite this, interaction is still unbalanced: the focus of attention is in the computer for typing, and in the toy for listening and watching its movements.

The stuffed toy has a set of hats with a small resistor whose unique value is read by the Handy Board (Martin, 1995). This microcontroller interfaces, via a serial connection, the physical toy

¹⁰Since SAGE was developed in a Macintosh-based platform, Macintalk was used for doing speech synthesis.

with the SAGE software that resides in a Macintosh computer. It allows the system to know which characters are loaded as well as controls the movements of the interactive programmable toy.



Figure 8: the programmable interactive rabbit and the Handy-Board.

Actuators and circuitry have been given to one of the stuffed animals, the rabbit, in order to provide feedback to the user (see fig. 8). They can: 1) move the ears from a straight up to a folded position in order to signal attention, 2) rotate shoulders in order to convey head and gaze direction, 3) light the pupils of the eyes to show interest, 4) deliver audio from a speaker hidden behind the mouth (Felsenstein, 1996). For example, to show attention, when the rabbit becomes a listener, its ears go up. As part of the authoring experience, children are able to program the physical behavioral responses of the toy as well as the verbal ones.

Section 4.1 presents and discusses user studies conducted with three different interfaces: a silent screen with the sage storyteller, a combined version with sage and assistant (toy) and the stand-alone interactive toy (Wizard of Oz technique). These studies were done in order to find children's interface preferences.

4. SAGE Storytellers: empirical research

"Les grandes personnes ne comprennent jamais rien toutes seules, et c'est fatigant, pour les enfants, de toujours et toujours leur donner des explications."

Antoine de Saint-Exupéry

Le Petit Prince

In order to explore how children use SAGE, in its interacting and authoring mode, empirical research was conducted¹¹. This chapter presents first, in the "Understanding Interactions" sub-section, studies that explore children's interface preferences and children's interpretations of traditional stories selected either through the matching algorithm or through a random matching. Second, in the "Understanding Constructions" sub-section, it presents results of children's participation in workshops where they designed and programmed their own interactive storytellers.

4.1 Understanding Interactions

In order to understand children's interactions with SAGE, two user studies were conducted¹². The first, called "Interfaces", was to explore interface preferences. The tested interfaces were:

- a stand-alone interactive toy (through a "Wizard of Oz"¹³ experiment)
- a silent screen
- a combined interactive toy - talking screen.

The second study, called "Interpretations", was to explore the relevance that children attributed to the comforting stories offered by the system. I looked at results for stories selected by means of a

¹¹Children and their parents signed a consent form in which the studies were explained to them and they gave their permission to be videotaped and have results published, keeping anonymity.

¹² Those user studies were conducted during the summer of 1996 in the context of a Fellowship at Interval Research Corporation.

¹³ A "Wizard of Oz" experiment is a simulation technique used to develop and test dialogue models prior to implementation. In each session, a "wizard" simulates the interaction strictly following an algorithm. The advantage of using the prototyping method is that problems of interaction can be solved before the final implementation of the system.

matching algorithm and those selected randomly. Both of these studies were videotaped. This chapter describes both user studies and presents qualitative and quantitative results.

4.1.1 Description of user studies

All the subjects —twelve children, boys and girls with ages between 11 and 13— had a Jewish background and were tested using the rabbi sage and his pet assistant, the interactive stuffed rabbit. Children were assumed to be very familiar with the Jewish tradition and the moral story's genre and knew what to expect from a counseling type of encounter with a rabbi.

4.1.1.1 Interfaces

The questions explored in the interface study were:

- What interface helps children feel emotionally engaged, share their personal stories and find easier connections with the comforting Hassidic stories ?
- What are children's interface preferences ?
- What kind of extracurricular activities correlate with liking SAGE ?

The user study was conducted testing three different conditions:

- 1) Silent screen: children can input information only through the keyboard. The system responds through a silent graphical cartoon-like representation of a rabbi on the screen.
- 2) Combined screen and toy: children can input information only through the keyboard. The system responds with text-to-speech when the conversation happens with the rabbi's assistant (an interactive stuffed rabbit) and recorded human voice when the cartoon-like character, the rabbi, offers a comforting story.
- 3) Interactive Toy: There is no screen. The rabbit maintains the conversation and tells stories to the children. A "wizard" simulates the speech recognition by typing what he/she hears into the system. The "wizard" also acknowledges the child's gaze and tactile information and accordingly controls the body movements of the rabbit.

Each subject was tested with each of the three interfaces and completed a questionnaire with a Likert scale test (see appendix A). After doing so they orally shared their overall experience in an extended personal interview. Conditions were counterbalanced as follows:

- Subjects 1&2: Silent screen, Combined, Toy
- Subjects 3&4: Silent screen, Toy, Combined
- Subjects 5&6: Combined, Silent screen, Toy
- Subjects 7&8: Combined, Toy, Silent screen
- Subjects 9&10: Toy, Silent screen, Combined
- Subjects 11&12: Toy, Combined, Silent screen

4.1.1.2 Interpretations

The questions explored in the “Interpretations” study were:

- how "smart" does the system need to be in order to allow children to make interpretations and find personal relevance in Hasidic stories?
- according to children's perception of story's relevance, is SAGE's matching algorithm performing satisfactorily ?

The user study was conducted with the silent screen interface only. The comforting stories offered by the system were randomly selected either by means of a matching algorithm or by a random matching. All the children blindly experienced both matching conditions. In order to explore the questions, the SAGE program asked the children if the offered comforting story made sense to them and what the connection was. To make sure that those answers were thought out carefully, the children were questioned later about their responses.

4.1.2 Results and Discussion

4.1.2.1 Interfaces Study

Among a total of 12 children, 50 % (6 children) preferred the combined interface, 33 % the interactive stand-alone toy and 17 % the silent screen (Fig. 9). This preference for the combined interface, as shown later, can be explained in terms of imperfection of speech synthesis and attractiveness of the toy. Results are not statistically significant; the number of tested subjects is too small to make generalizations.

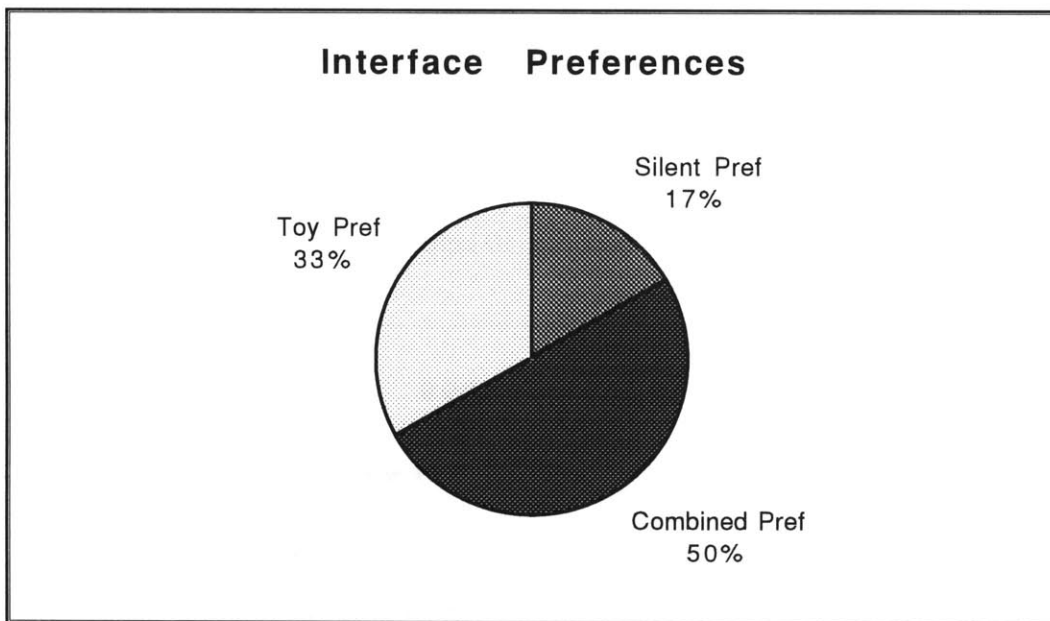


Figure 9: The combined interface was preferred by children.

The argument given by children who preferred the combined interface is well represented by Marie¹⁴, a fifth grader: *“It is neat to use the computer and also hear the bunny talking and see him moving. If I didn’t understand some of the words I could just look on the screen and read them. The rabbit was cute and it is better if it moves because it expresses itself a little more and sometimes it even makes it easier to understand.”* Marie's statement suggests that technical

¹⁴All children's names have been changed.

problems, such as the bad quality of speech, make the combined interface better than the stand-alone toy.

Children who said that they do not play with stuffed animals liked the toy interface less than children who do play with stuffed animals. Privacy seems to be the main issue for this group of children. Amy, a sixth grader who preferred the silent screen interface, puts it this way: *“I like to be a little more private. I don’t like to say things out loud because everybody can hear. The bunny talks and people can hear my story.”*

All the tested children said that in general they like to read. However, not all of them like to do it in their free time. A significant difference was found between children who enjoy reading in their free time as one of their favorite activities and children who don’t ($p < .05$). This last group of children liked best the overall SAGE environment (see Fig. 10 below).

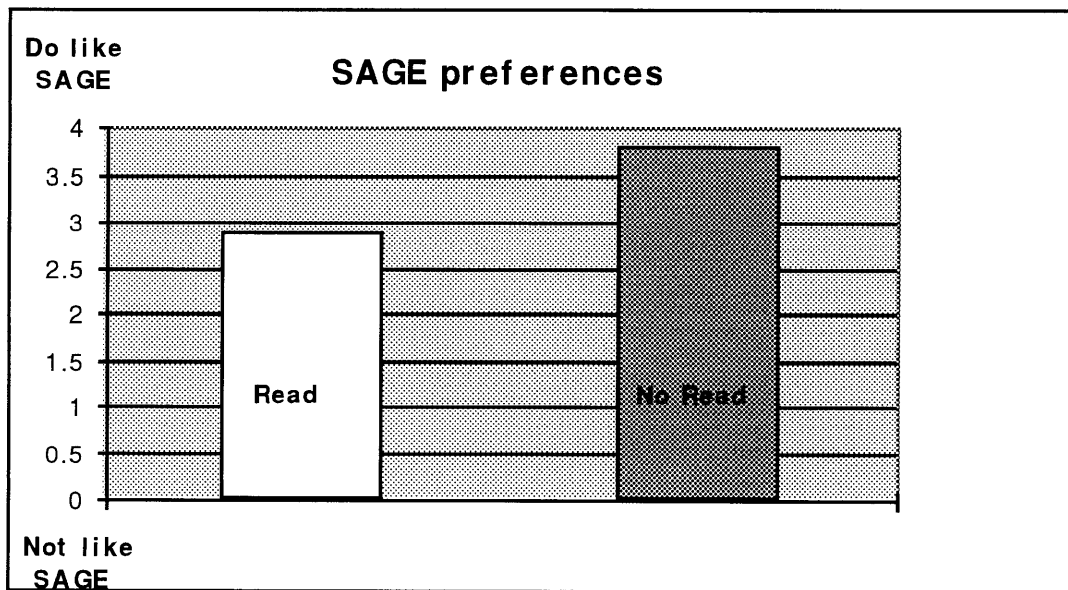


Fig. 10: Children who do not like to read in their free time liked SAGE more than those who do.

Surprisingly, children who do not choose to read in their free time preferred the silent screen interface, where the only possibility of engagement is through reading (see fig. 11 below). However, there was no statistical significance found.

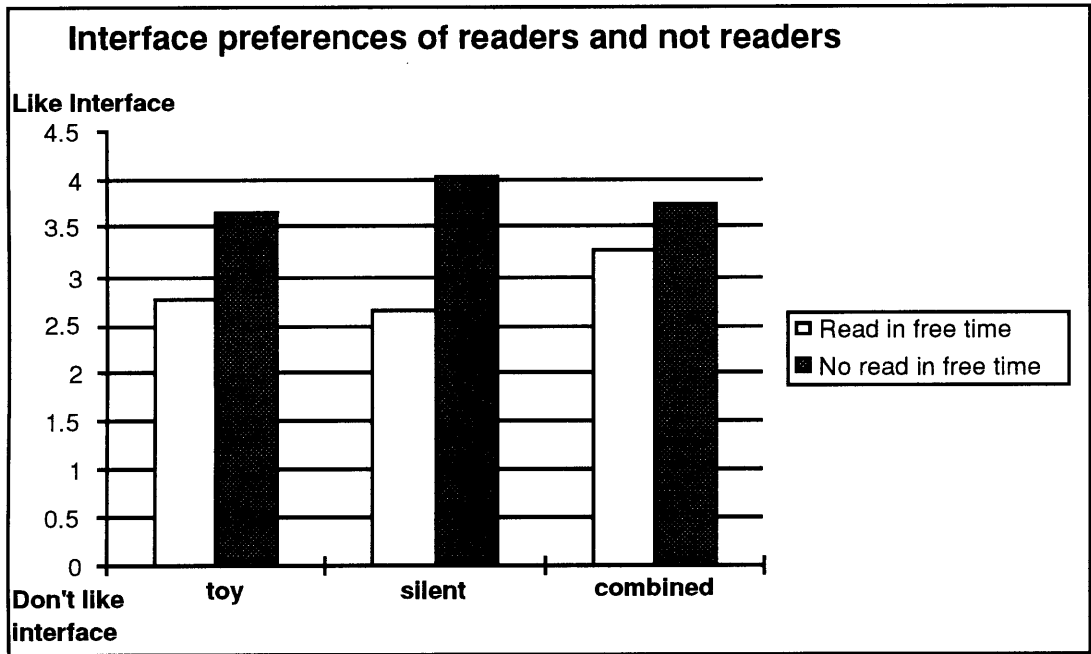


Fig 11: Children who don't like to read in their free time preferred the silent interface.

The tendency shown above might seem surprising. Laura, a representative of the group of children who do not like to read in their free time, gives an insight that helps us understand this preference for the silent screen: “When *the rabbit was talking*, it was a little bit harder to understand [the stories] than reading them. They didn't stick in my mind as well.” Laura refers to the bad speech quality of the text-to-speech synthesizer. Children who do not like to read in their free time are not so comfortable with just hearing a story. They also want to be able to follow it by reading it on the screen. Taking this into consideration, it is possible to venture that SAGE can be used as a tool to introduce children to the world of language and reading.

Children who in their free time like to do social or communicational activities, i.e. talking on the phone and getting together with friends, preferred the soft interfaces: the interactive toy and the

combined interface (Fig. 12). However, these results are not statistically significant and are only an observed tendency of the tested twelve subjects. Interacting with the toy is seen by the children as an action close to the experience of talking with a human in the sense that there is no distance imposed by the keyboard, and the body movements of the toy also seem to emulate human communication. However, children pointed out some of the key communicational cues missing. Robert, a 12-year-old who expressed his preference for the interactive toy said: *“I liked better just the doll, with no computer. But there are some really awkward sort of pauses and stuff where it might not have picked up what I said. So, I guess it was harder to have a real conversation. Well, I mean, what would happen is I would say something and just sit there, and the doll showed no signs of picking up what I said. I wasn't sure whether to repeat it or say it again. If the bunny just shifted positions every time it picked up what you were saying, it would be a lot easier.”* Robert's request addresses the need to incorporate body back-channel as well as verbal back-channel. This is important because, as Gombert (1992) suggested, children need both verbal and physical feedback in order to communicate well: “If children produce ambiguous messages is because they do not rely on the verbal channel alone. They count with the physical presence of the interlocutor.”

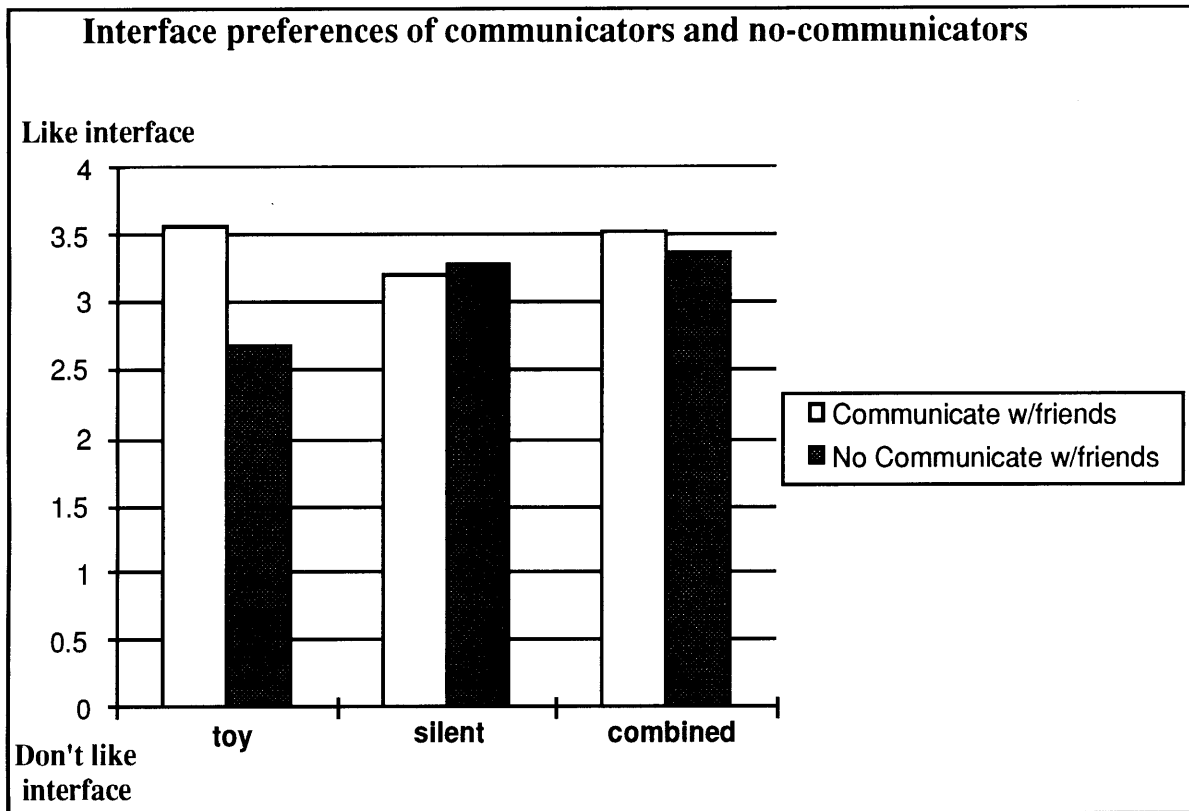


Fig. 12: The toy and the combined interfaces are preferred by children who in their free time communicate with friends.

Marie, who preferred the combined interface, says: *“The screen [silent interface] didn’t seem as comfortable in a way because it was just words on a screen. It didn’t feel like somebody was talking to you.”* Daniel preferred the interactive toy interface but had certain concerns: *“Well, I’d take the idea of being able to interact with just the rabbit because that was fun. I liked it being oral because then you could just talk and you didn’t have to worry about how you wanted to write. But make it easier to understand.”* Daniel’s comment refers to the bad quality of the speech-synthesizer.

Aaron, a ten-year-old boy who engaged with the toy in a very conversational style¹⁵, says: “The screen was sort of impersonal. I had no sense of talking to a person [...] and you’re not inclined to say what you would really feel or want to tell someone. With the computer it’s hard to get away from the fact that you’re typing something in and you’re not talking to somebody. And there’s no sense of them being there. It’s just a screen. And it’s really hard to take away that.” Most of the children seem to prefer the soft interfaces.

Not surprisingly, children who have troubles sharing their concerns and do not like to tell personal experiences needed more turns or questions from the storyteller in order to open up and share their personal stories, independent of the interface. This tendency is shown in Fig. 13. Note that the baseline is 1 since the storyteller always asks at least one time.

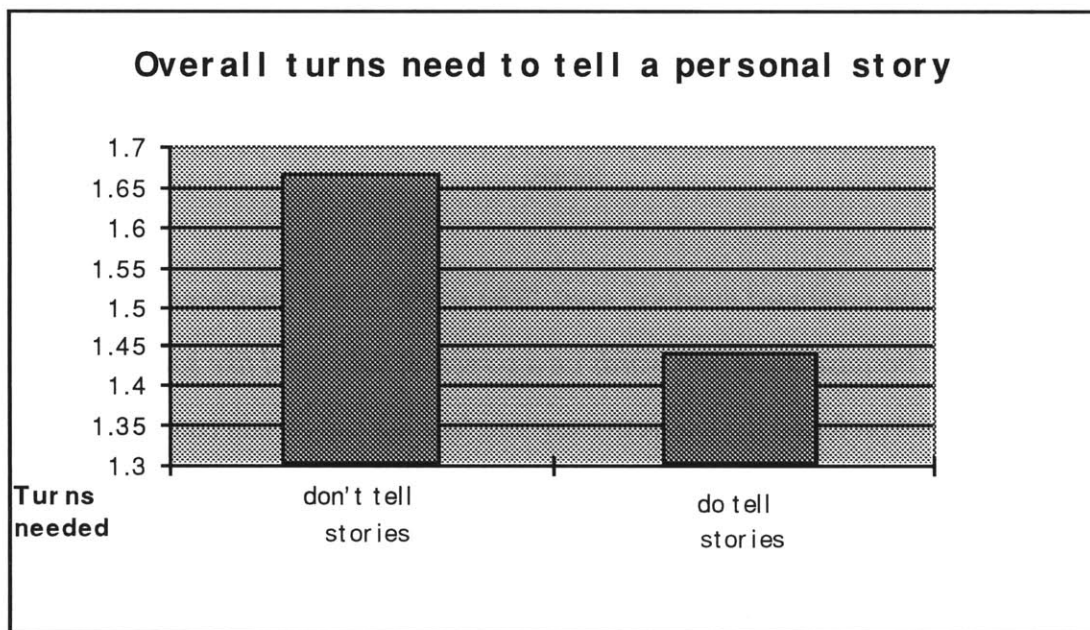


Fig. 11: Children who don't tell personal stories needed more turns to open up.

However, figure 14 shows the tendency that, using the silent interface, children needed more turns to open up and tell a personal story. The presence of an interactive stuffed animal seems to foster

¹⁵ Aaron 's interaction with the toy was especially interesting in the natural way in which he engaged with the toy, not only asking the toy questions which they toy —of course— didn't answer, but also commenting on how cute it was and how well its hat fit. Aaron also talked with the toy using gestures and smiles and not just words.

children's engagement since, overall, with both the combined and the toy interfaces children needed an average of 1.2 questions from the storyteller in order to share their personal problems.

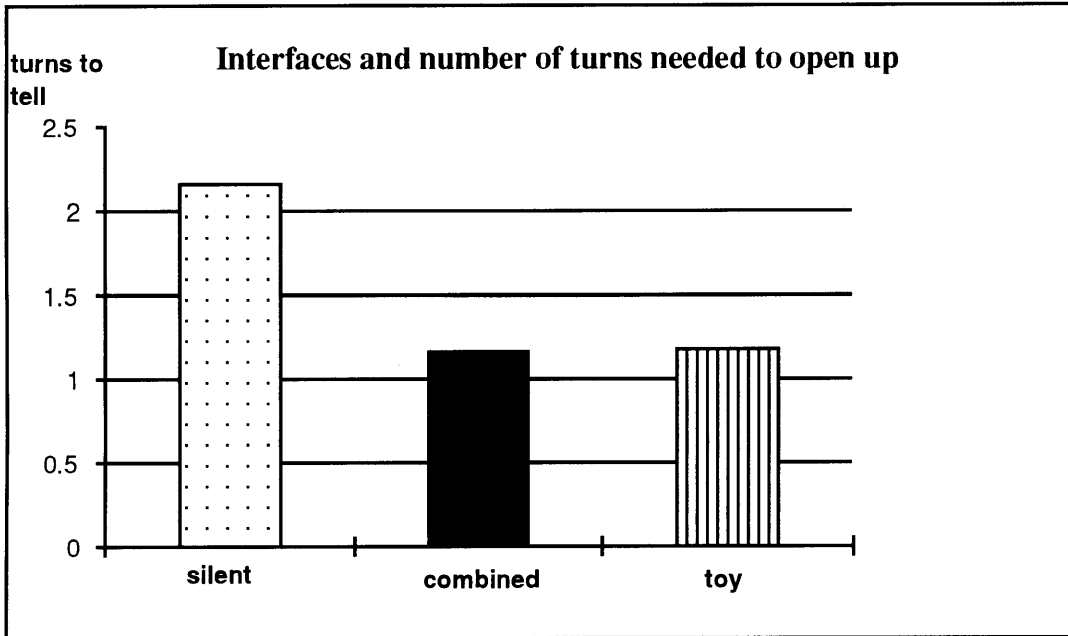


Fig. 14: Children needed less turns to open up with the toy and combined interface

Aaron explains why he would like to take the interactive toy with him: *“If the bunny was at home then I'd probably go to him, or my mom or dad depending on my problem. If I was confused about something not very serious I probably would ask him, because it's not really necessary to bring your parents into everything you do. But if I had any thing more serious I'd definitely talk to my parents. But because of a friend's party or a soccer practice I don't need to. Only if it is a little more serious than soccer.”* Aaron's explanation is relieving. It shows that children do not think of SAGE as a replacement of their parents or listeners, but as another resource to enable them to share their problems. SAGE was conceived with that purpose in mind, and was based on the assumption that today, most of the children know that computers, by themselves, are not good counselors for delicate issues¹⁶.

¹⁶ When, in 1984, Sherry Turkle did her study about children's conceptions of the "intelligent machine", the personal computer was a novelty. Today most of the children, especially fifth graders, have pretty good intuitions about how computers work and know that they need to be programmed by someone in advance. However, they might still regard the computer as "something" worth listening to.

4.1.2.2 Interpretations Study

By setting the appropriate socio-cultural background and setting the right psycho-social expectations, a system like SAGE doesn't require complex matching algorithms nor natural language processing. Children who know what to expect from traditional stories (are familiar with the genre) and from encounters with sage storytellers, are able to make connections and construct meaning out of the offered comforting stories. They also understand what is expected from them when asked to share a personal story.

Finding sense in the stories and making meaning out of them is one of the main requisites for SAGE to succeed in both its learning and entertainment goals. Children who found sense in the stories offered by the computer had a perception of having learned better than children who couldn't make sense out of the stories (Fig. 15). Children found different things they learned: the stories, how to resolve their problems and how the technology works. Each child was requested to specify what he or she considered as "valuable learning" while using SAGE. Even though the number of tested subjects is small—twelve— there is a statistical significant correlation between finding sense in the stories and children's perception of having learned with SAGE ($r = 0.84$, $p < .01$). This result might seem intuitive, but, it is important to report it since learning is associated with understanding and making interpretations.

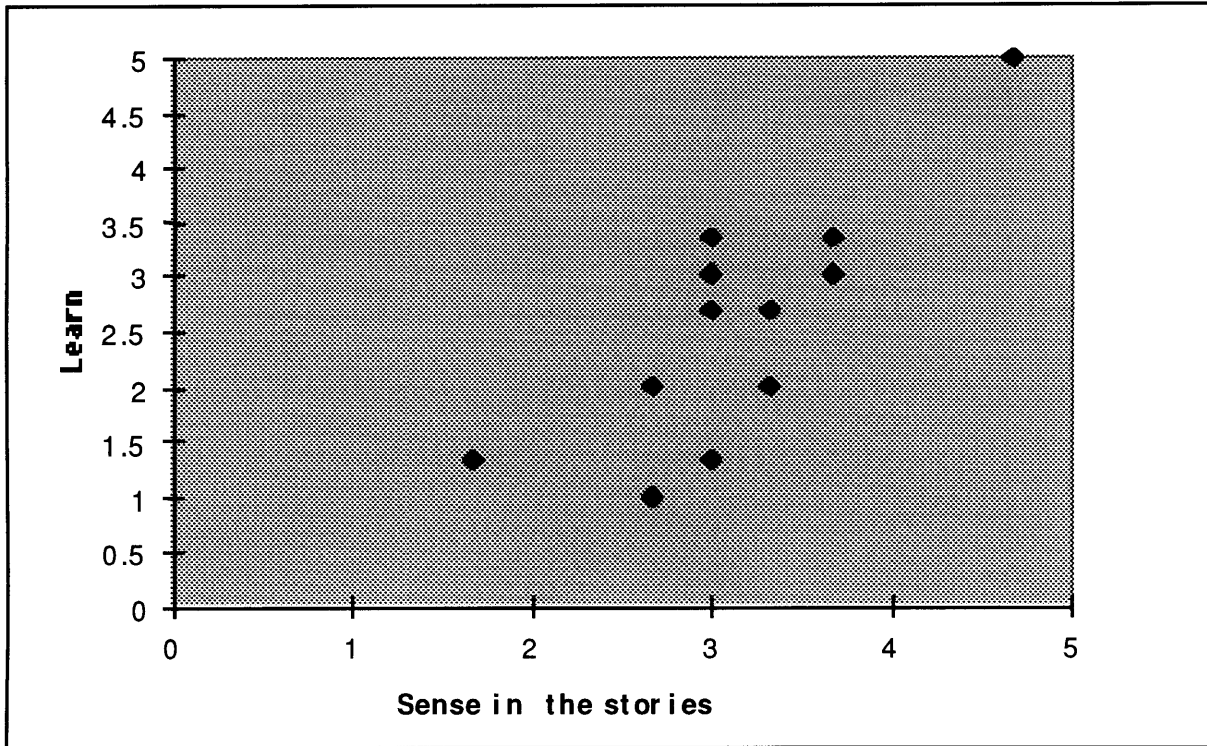


Fig 15: Correlation between making sense out of the stories and self-perception of learning with SAGE.

There is also a significant correlation between liking the system and finding sense in the stories, ($r= 0.79$, $p < 0.1$). Children who liked the system better are children who could make sense out of the offered stories and were more actively engaged in the process of making interpretations (see fig. 16). It may also be that children who liked SAGE tried harder to make sense out of the stories. Peter says: *"I liked how during the stories at the end he asked you how does it relate to your story. And so with the clear voice [recorded human voice], it's much easier to relate things, because you understand a little better."* In the same lines, after interacting with the rabbi, Bernard says: *"I guess sort of the nature of the advice I received is so that I can come to a conclusion, instead of being told what the conclusion should be."*

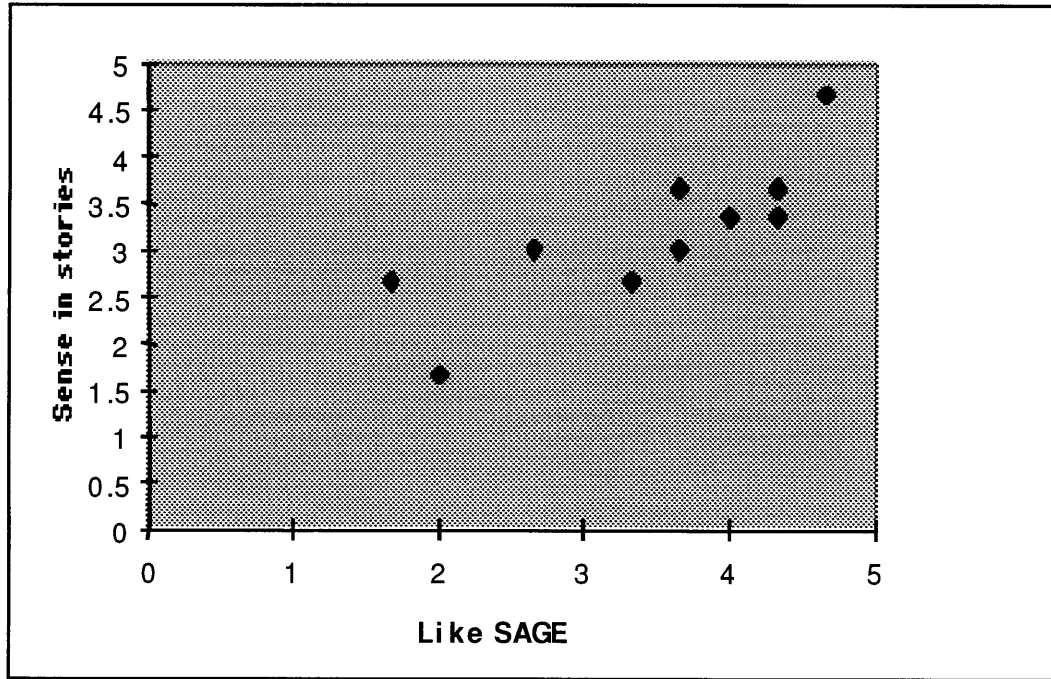


Fig 16: Correlation between liking SAGE and being able to make sense out of the stories.

There is a tendency towards the more story events in user's story, the more developed the personal narrative, the better the matching algorithm performs, and the higher score the matching received. The matching shows a tendency to be affected by the amount of information (story events) given by the user. In figure 17 we can see the tendency that the more information, the higher the score.

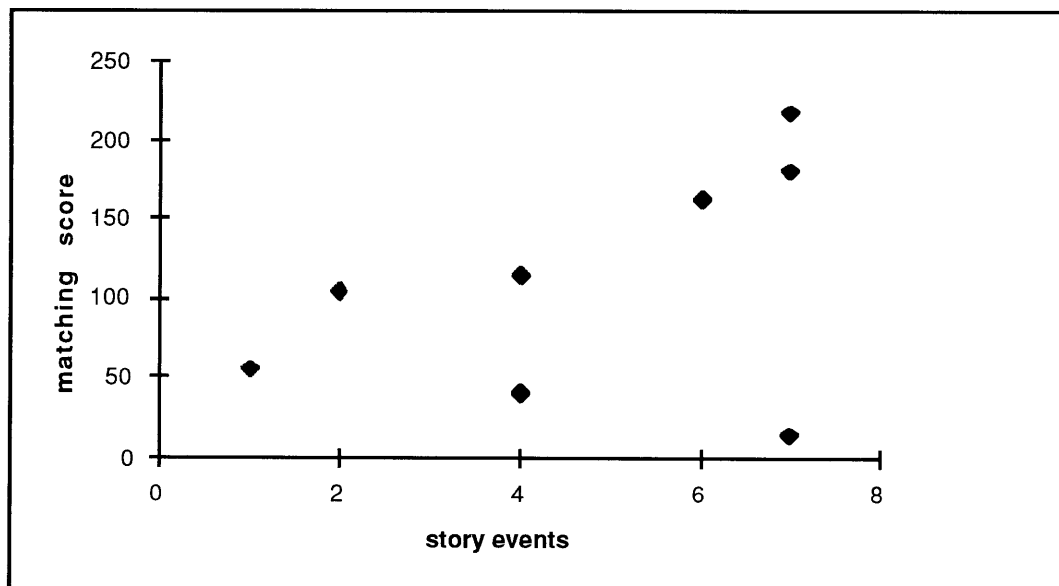


Fig. 17: correlation tendency, the more story events in user's story, the better matching algorithm performance.

In the future, it might be interesting to do a correlation between the score of the matching algorithm and the user's perceived relevance of the selected database story. Figure 18 shows a tendency that children needed more comforting stories offered by the computer in order to find connections with their own stories with the random matching than with the matching algorithm. There is no statistical significance, but the algorithm may help the children to find connections sooner.

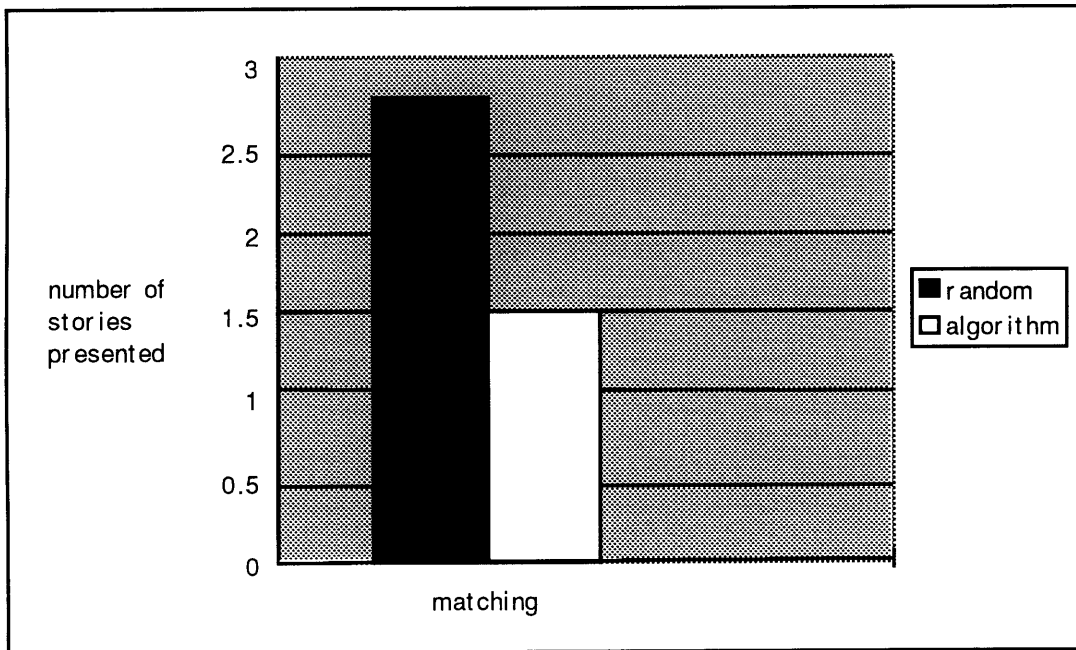


Fig. 18: children needed less stories to find relevance with the algorithm than with the random matching.

Figure 18 shows that the matching algorithm might be useful for selecting relevant stories. However, I observed a tendency that when the user tells a personal coherent and cohesive story, relevance is found independently of the performance of the matching algorithm to select a comforting story.

A discourse analysis of the logs —saved interactions with SAGE— showed that children's stories shared with the system can be divided into two groups: 1) coherent and cohesive personal stories, in which story events unfold keeping the same topic and maintaining the same referents; and 2) non-coherent and non-cohesive stories that are not always personal. Children who emotionally

engaged with SAGE by telling personal coherent and cohesive stories were more likely to make connections with the comforting stories offered by the system, independent of the score given by the matching algorithm or the random selection method.

Below I present three cases that support this. The cases represent three different situations in which a comforting story was selected: with a high score, with a low score and through a random matching. Logs show that in all three cases, independent of the matching technique, children were able to find personal relevance.

Case 1: Carlos, a ten-year-old, told a coherent and cohesive personal story and the matching algorithm returned a story with a very high score of 217. Carlos found that story relevant for his situation.

SAGE: Nu, Shalom... oy vey...I can't remember your name, you are ?
USER: Carlos
SAGE: You seem a little shy , Carlos. I also was shy to tell stories, but since my father and my grandfather were Hasidic Rabbis I knew I had to become one. That is the way it is.Nu,Carlos, how old are you ?
USER: 12
SAGE: Oy vey, I am 78 years older than you. You know Daniel , a story is more than a story...a story has power. Nu, what is troubling you ?
USER: Nothing really
SAGE: No story ? Nu, Carlos, what brings you here?
USER: Well sometimes I have trouble inviting people to my house, even though I always have fun when I do.
SAGE: I see Carlos...what else do you have to share with this old rabbi?
USER: Well lots of times my parents try to make me invite someone over, which I don't like.
SAGE: Oy vey... go on, Carlos.
USER: But when they do make me and I finally invite someone over I have fun. But whenever they don't make me I don't do anything. I want to know how I can have someone over without my parents making me.
SAGE: Oy va voy, Carlos let me see if this rabbi understands. Sometimes you have trouble inviting people to your house, even though you always have fun when you do. Well lots of times your parents try to make you invite someone over, which you don't like. But when they do make you and you finally invite someone over you have fun. But whenever they don't make you don't do anything. you want to know how you can have someone over without your parents making you. Is this right ?
USER: Yes

SAGE: Your situation reminds me of a story. Remember, there is power on the stories. The Vorker Rabbi discussed the saying in the Ethis which reads: "He who says, What is mine is mine... , his son is a neutral character: some say, this is a character like that of Sodom." He said: "A man is asked to give charity. He answers: "What is mine is for mine. I prefer to assist members of my own family.' This is a sign of a mediocre personality; one of a higher character assists strangers as well. Some other men when asked to make a donation to charity, 'say' they will do so later, but they actually gave nothing. They are comparable to the inhabitants of Sodom." Carlos, do you see the point of this story related to your own story ?

USER: I think so.

SAGE: Good, Carlos. Please share with me your thoughts. I am curious

USER: Well I think when I don't have anything to do I should invite someone over instead of prolonging the situation until it is too late.

SAGE: Baruch Ha Shem, you got the power of the story... So look, I have to go now. Carlos, don't stop telling stories. Maybe someday you might also become a Hasidic Rabbi. May the Lord, Source of Life, bless you Carlos with peace, and may you find your inner peace. Amen

CASE 2: Erica's and Ben's logs support the same statement but in exactly the opposite way from Daniel's case. Both children told a coherent and cohesive personal story and the story selected by the matching algorithm showed a very low score (34 in Erica's case and 17 in Ben's). However, both found the story relevant and were able to make personal connections. Excerpts from their logs are presented.

USER: I had a problem in Hebrew school where I didn't know the alphabet that good and everybody else did from the year before but I wasn't there the year before.

SAGE: Please continue, Erica, this may not be a synagogue but we still have no secrets.

USER: Every body teased me and made fun of me

SAGE: Nu, keep talking, Erica.

USER: I'm done

SAGE: Rabbi Sholom DovBer was deep in thought, struggling with some elusive idea deep in the recesses of his mighty mind. A bowl of soup had been set before him some time earlier, but the Rebbe was in another world; sharp lines of concentration plowed his forehead as he sat gazing into the bowl and slowly stirring the soup with his spoon. The Rebbe's servant, who assumed that the Rebbe must be searching for the egg noodles, exclaimed: "Rebbe, dig in further! The lokshen lies deeper down." A wave of contentment passed over the Rebbe's tensed features. "Thank you," he said to his servant, "You have revived my soul."

SAGE: Nu, Erica, do you see the point of Rabbi Grois's story related to your own story?

USER: The servant sort of made fun of the guy because he couldn't find the noodles like people made fun of me

SAGE: Erica, could you explain me the connection ? I don't get it.

USER: the servant sort of teased the guy like everybody teased me

USER: My brother and I don't get along often. How can I help fix that? SAGE: Please continue, Ben, this may not be a synagogue but we still have no secrets.

USER: Well, we fight a lot and occasionally say things we may not mean.

SAGE: Oy vey... go on, Ben.

USER: It is often hard for us to get along during prolonged interaction, like car rides.

SAGE: Two brothers lived in Jerusalem in the same house. One of the brothers had a wife and children, while the other brother remained unmarried. At harvest time, they divided all the work equally. One night the unmarried brother thought "I have only myself to care for, while my brother has a family. Why then, should our portions be equal when his need is greater than mine?" The brother took some sheaves from his pile and added them to his brother's pile. On that same night, the married brother thought, "It is not right that my brother and I have equal sheaves, for I am happier and he is all alone." So the married brother put some of his sheaves on the single brother's pile. Next morning the brothers were both surprised, for the piles were still equal.

SAGE: Now, do you get the idea?

USER: Yes

SAGE: Ben, could you explain me the connection ? I don't get it.

USER: The brothers each demonstrated kindness toward each other and all was well. Thus, if I be nice to my brother, he will return the kindness.

CASE 3: Carl and Whitton told a coherent and cohesive personal story. The offered comforting stories were selected through a random matching. Both children found the story relevant for their situation. The following are excerpts from their interaction logs.

USER: Well at my old school I really liked my teachers and I'm not sure if I'll like the teachers as much that's all

SAGE: Let me tell you, Carl. A man asked the Kotzker Rabbi to pray for him in order that his sons might study the Torah diligently. The Rabbi replied: "If your sons will see that you are a diligent student, they will imitate you. But if you neglect your own studies, and merely wish your sons to study, the result will be that they will do likewise when they grow up. They will neglect the Torah themselves and desire that their sons do the studying. You understand now, Carl ?

USER: well that just need to be confident and if I just be myself things will turn out OK

SAGE: Carl, could you explain me the connection ? I don't get it.

USER: That if I act normally and not get up tight so will the other people at the school just like in the story if the man was a good example for his sons then they would follow in his footsteps.

USER: Ok, last year at my Hebrew School we had our annual bible quiz. I was one of the top students in my class so I we chosen to be

in the Bible Quiz. I was the second to oldest on my team. As it turned out I was the only person who had studied on my team so I had to answer all the questions. which made it really unfair. When the Bible Quiz was done our team got third place which made me really upset because I had wanted to get first place that year. I have been on the Bible Quiz each year at my Hebrew school. My friends told me not to be disappointed but I still was.

SAGE: The Romans introduced many foreign practices into Israel when they conquered the land. One of these practices involved "games" that consisted of contests between men and wild beasts or between men. When the fighters faced each other, they were to fight to the death. When one gladiator was about to kill another, the victor would look up to the audience for advice, waiting for a "thumbs up" , which was a death sentence for the defeated gladiator. Jews were horrified with this cruel activity. Rabbis were almost unanimous in declaring that Jews should not attend these events voluntarily. No Jew, it was argued should seek to find pleasure when one human being kills another human being. Rabbi Nathan, however, disagreed with this view. He said that Jews should not only go to these sporting events, but once there, they should shout. When asked why, Rabbi Nathan explained that a Jew should go and always scream "thumbs down!" By doing so it was possible that a life could be saved.

SAGE: Nu, Whitton do you get it?

USER: Sort of. That every thing has many sides to it and that maybe it wasn't all my team's fault.

These three cases show that, independent of the matching method, children where able to find relevance with their own stories. Humans are meaning-making machines and the more we think about our problems, the easier it is to find the answers in ourselves, and interpret comforting stories according to our needs. Therefore, complex matching algorithms might be useful but not necessary in this type of application¹⁷.

4.2 Workshops: Understanding Constructions

In order to understand children's design and creation of their own meaningful storytellers, workshops were conducted. Individual extended interviews were done, before and after the workshops, to explore the children's notions of identity, and storytelling as a communication experience. This section describes the methodology used in the workshops, the building and designing experience, and discusses results.

¹⁷For the same reason that people read the Chinese fortune cookies and very often find them relevant for their situation.

4.2.1 Description of workshops

Two different kinds of workshops were conducted with fifth graders. First, a pilot study was held with a group of ten children from the École Bilingue in the greater Boston area. The second study consisted of two two-day workshops in an after-school program conducted at the Media Laboratory.

4.2.1.1 The pilot workshop

The pilot study was done to test the SAGE programming language and the methodology with fifth-graders before designing and conducting the after-school workshops. During the pilot study, children from the École Bilingue worked together and built Powl the Owl, the pet assistant of Irene, a grandmother who tells La Fontaine's fables in French. Children selected and recorded twenty one fables —this idea was suggested to the them. Children were divided into three groups, each in charge of one part of the creation process: 1) the character's design, 2) the conversational structure and 3) the database of stories.

The pilot study lasted over a month, with once-a-week meetings of two hour each. A final presentation for sponsors of the Media Lab was given by the children. The first meeting was intended for children to become familiar with SAGE , by interacting with the Hasidic rabbi and the Taoist master, and for us to explore difficulties with the tool as well as with the empirical methodology. In order to explore the children's notions of communication we did a role-playing in which one participant pretended to be the user, another the computer (grandmother) and a third, the stuffed owl (the pet assistant). The rest of the meetings were devoted to the design and construction process. Below is a log of an interaction with the characters:

```
SAGE: Do you have an appointment ?  
USER: yes  
SAGE: Hi I'm Powl, I'm 795, how old are you?  
USER: 10.  
SAGE: Where are you from?  
USER: Paris  
SAGE: What are you going to have for dinner?
```

USER: chicken
SAGE: Who are you going to vote for?
USER: I don't vote
SAGE: What's your favorite farm, jungle, or forest animal?
USER: fox
SAGE: OK. So let me call Grandma Irene, and she'll tell you a story about your life in French, and I will translate.
SAGE: Mr. Crow, perched in a tree, held in his beak a piece of cheese. Mr. Fox, attracted by the smell, began to speak in terms roughly like these: "Hullo ! I mean, good morning, honorable Crow, you look uncommonly well, indeed you look a veritable Romeo. Honestly, if it were not for one thing you would be the phoenix of



our woodland birds: your feathers are gorgeous -but how well can you sing ?" At these words the crow, beside himself with pleasure, opened his big mouth to show off, and dropped his treasure. The fox snapped it up in an instant, remarking: "My dear sir, learn the hard way that all flatterers live at the expense of those with a credulous ear to give. A lesson cheap, surely, at the price of your lost cheese-slice." The crow vowed (rather late in the day) never again to be so abused.

In this log we can see that Powl, the Owl, doesn't build a coherent and cohesive discourse while "interviewing" the user. The character jumps from one question to another without giving feedback or keeping a thematic unity or continuity. It is also noticeable that only the last question, "What is your favorite farm, jungle or forest animal?" is related to the fact that the grandmother tells fables. And this question was added at the end of the project, by the "database group".

The lack of continuity may be due to the fact that the children worked in parallel separate groups; therefore, the team in charge of creating the characters was not fully aware of what kind of questions the "conversational structure group" was posing and how the "database group" was indexing their stories. When all three groups got together to share their contributions they realized that there was something missing: they were not able to make the matching between user's

interview and the stories in the database because there was no adequate prompting to the user. To solve this problem they decided to add the last question mentioned above.

From this pilot experience I learned that in order to conduct more successful workshops (from a product as well as a process point of view), and in order to collect useful data, I needed to:

- have children choose and work on their own individual and meaningful storytellers: this would facilitate the exploration of identity issues and may lead to some observation of how children represent themselves or the images of what they want to become, through their characters.
- invite children from different schools and backgrounds in order to observe diversity of projects, learning styles and difficulties.
- avoid separating children into task-oriented groups; doing so doesn't allow them to participate in the whole process of creating an interactive storyteller.
- make the SAGE programming language more flexible in order to permit the inclusion of different ideas and projects: for example, the children from the École Bilingue wanted to make Powl, the Owl, the English translator of the French grandmother. However, since the technology didn't allow that flexibility, they had to content themselves with recording the fables in French and making them appear in the talking balloon in English —which was very confusing.
- have a real audience for children's projects: from an engagement point of view, children were very excited by the fact that a real audience interacted with their characters. The fact that the audience was composed of adults, mostly sponsors of the Media Lab, made it even more interesting and gave children a sense that they were doing "serious work". From a learning point of view, having an audience very different from themselves was important for what I will call, following Piaget (1962) and Hickmann (1987), "decentering" (see section 5.4). This

allowed them to debug and provide branching structures to resolve communicational breakdowns when the scenario given by the user was different from the one they conceived.

- conduct extended in-depth interviews on an individual basis in order to thoroughly understand the children's viewpoint regarding identity, storytelling and communication, as well as their designing and building process.

4.2.1.2 The after-school workshops

The design and conduct of the two-day workshops was based on the experience during the pilot study as well as on more careful methodological planning. The workshops were conducted with two groups of four children: two girls and two boys per group, one pre-study personal interview, one post-study personal interview, and one demonstration for the parents given by the children. Each child designed and programmed a chosen meaningful storyteller in an individual computer and kept his/her designer notebook with ideas, problems, etc. Children met as follows:

- Pre-study and post study (1.5 hour- Individual)
- Workshop Day 1 (7 hours - lunch and snacks included)
- Workshop Day 2 (7 hours - lunch and snacks included).
- Demonstration for parents given by the children (1 hour)

Following the literature review presented in chapter 2 and the experience during the pilot study, the questions raised were (see Fig. 19):

- SAGE impact on storytelling: By using SAGE, do children explore their understanding of the structure and dynamics of personal storytelling ?
- SAGE impact on communication awareness: By using SAGE, do children increase their ability to understand personal storytelling as one example of a communication situation ?
- SAGE impact on identity formation: By the process of building their own meaningful storytellers, do children develop self-reflection skills ?

- SAGE impact on modeling skills: By the process of building meaningful storytellers, do children develop abstract, structured thinking useful for programming as well as for storytelling ?

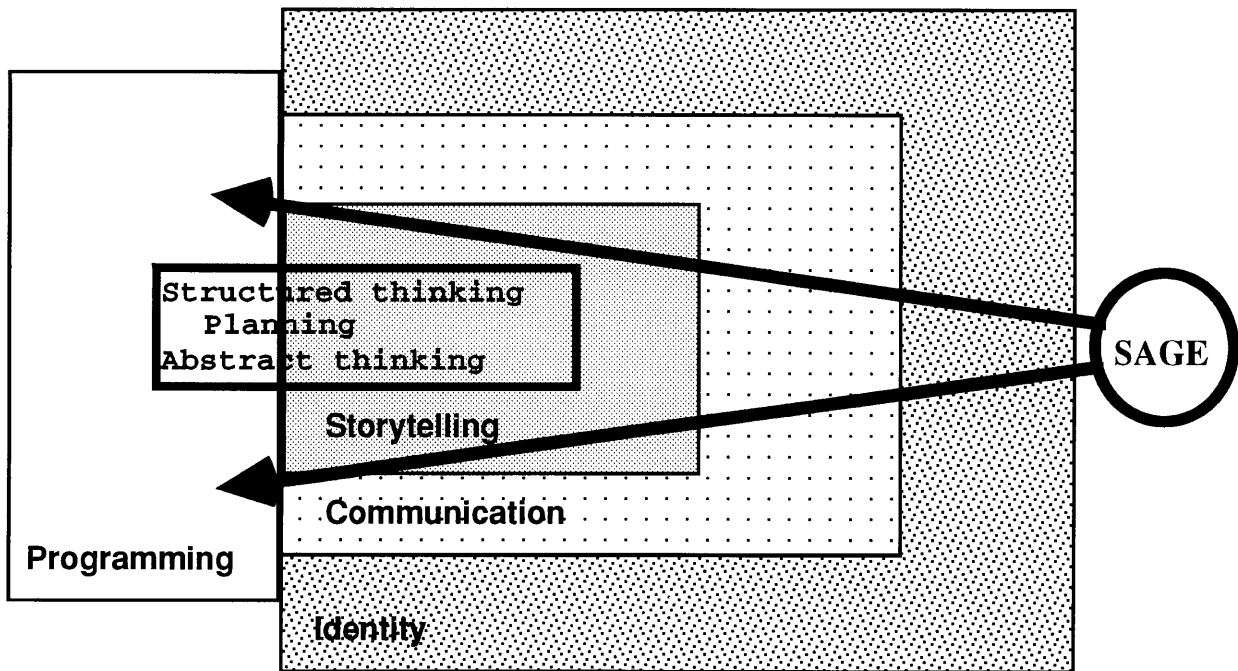


Fig. 19 shows how it is hypothesized that SAGE has some impact on identity, a little more impact on communication awareness and even more on storytelling development. Storytelling and programming required and develop structured and abstract thinking, as well as planning. Those skills are leveraged by the use of tools like SAGE that involve and integrate both activities.

The methodology used was an ethnographic approach with a natural observation method, extended personal interviews and an experimental task. In order to avoid what Papert calls "technocentric questions", the methodology was centered on what children do with SAGE and not what SAGE does to children (Papert, 1987). The study included:

- observation of children using SAGE in both the authoring and interacting modes
- observation of children's discussions during the authoring process
- extended personal interviews ¹⁸ (see appendix B)

¹⁸The interviews served to explore what are the children's notions of roles, language use, turn-taking, parts of interaction and sense of listener. It also served to learn how children think the computer works, in order to assess their programming awareness and differences perceived before and after the authoring process.

- an experimental task¹⁹
- analysis of logs generated by interaction with storytellers
- analysis of project progress
- analysis of children’s personal designer notebooks²⁰
- focus sessions to show children how to use the SAGE authoring level
- videotaped workshops (lunch time included since it was very likely that conversations arise in that informal setting) and recorded interviews

The following table shows in more detail how the workshop was conducted and the data collected:

Meet	Activity	Methodology	Research Goals
Pre-study Individ. (1:1/2)	<ul style="list-style-type: none"> • Interview: Cultural Background, self-awareness, programming & storytelling interests. • Child's interaction with SAGE in "Interaction Mode". • Task 1: Choose the picture that resembles interacting with SAGE and explain why. • Interview: Notions of storytelling and communication found in SAGE. How SAGE works ? • Interview : Deciding on sage to build. • Designer notebooks: given to children to write down their ideas and bring it to the workshop. 	<ul style="list-style-type: none"> •Oral personal interview •Analysis of computer logs to detect personal engagement •Oral personal interviews 	<ul style="list-style-type: none"> •Initial data to explore hypothesis 1, 2 and 3, 4 (numbers correspond to above hypothesis). •Initial data to explore hypothesis 3.
Workshop 1 2 groups (7 hour)	<ul style="list-style-type: none"> • Group focus session: showing the tool SAGE Authoring Mode • Character design with SAGE • LUNCH • Storytelling structure and script design with SAGE • BREAK • Story selection & categorization with SAGE 	<ul style="list-style-type: none"> •Observation/coaching •Observation of process with interviews and sharing of the designers notebook 	Data on building process to explore hypothesis 1, 2, 3, 4.
Workshop 2 2 groups (7 hours)	<ul style="list-style-type: none"> • Story selection & categorization with SAGE • First debugging • LUNCH • Demonstration for the parents • Second debugging 	<ul style="list-style-type: none"> •Observation/coaching 	Data on building process to explore hypothesis 1, 2, 3,4.
Post-study Individ. (1:1/2)	<ul style="list-style-type: none"> • Child’s interaction with their own created storytellers and other’s. • Task 2 and interview : choose the picture that resembles authoring with SAGE and explain why. Self-reflection about their experience. 	<ul style="list-style-type: none"> •Analysis of computer logs to detect engagement. •Oral personal interview 	Final data to explore hypothesis 1, 2 and 3.

¹⁹Children were presented with pictures and had to chose the one showing the activity that is most similar to the one they performed while interacting with SAGE. This was to explore how children think about their experiences with the computer. The same task was repeated in the post-study to see differences and explicit references to SAGE.
²⁰ Children used their designer notebooks to write ideas and problems before, during and after the authoring process.

4.2.2 Children's creations: some examples

This sub-section presents pictures of the storytellers created by the children, interaction logs, and comments about the characters and —and their designers. For a deeper analysis and discussion of learning experiences see chapter 5. From a total of eight storytellers built during the workshops, three are based on actual characters or people: Doug, a cartoon character from the world of media; Tera Randof, a mixture between a real sport figure and family members of the author; and Shaquille O'Neil, a well-known basketball player. The other five characters are fictional, although two of them, Spot and The Big Orange Fox, clearly tell stories based on the authors' personal experiences. As Erik Erikson (1950) wrote "In play-acting we can be what in life we could not or would not be." SAGE supported children's projections of fears, feelings, interests and role models. I also encouraged exploration of notions of communication while observing breakdowns in the designed conversational flow.

During the authoring experience none of the children used the pet assistant—it made the conversation structure more complex because instead of two turns (S) and (U), children would also need to include (A). But most of them expressed that next time they want to have the rabbit.

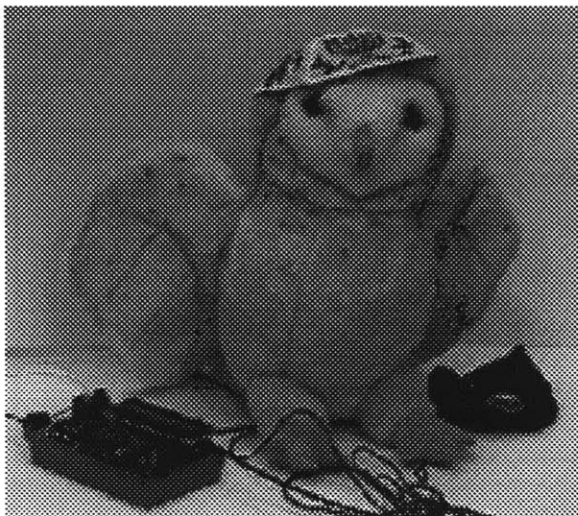


Fig 21 shows Powl, the Owl

Only the group from the École Bilingue, during the pilot study, used a stuffed animal (see fig. 21). Maybe that was due to the fact that a team of three children devoted all their efforts only to create the conversational structure. Below I will present some of the characters created by the children who participated in the after-school workshops.

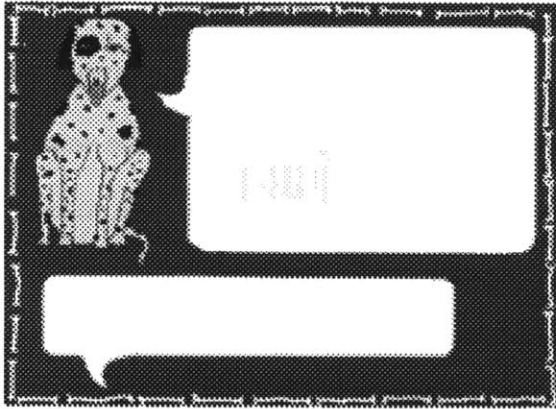


Fig 21: Spot, the dog

Spot, the dog, was designed by Marcel, a fifth grader from the greater Boston area whose favorite classes at school are Social Studies and spelling. Marcel wants to become an architect when he grows up because he loves to make things. First he drew the dog on paper, then scanned it in the computer and colored it in Photoshop. Marcel spent a long time working on his drawing and was very careful

with details. Marcel used the SAGE's recording feature as a mechanism to help him revise and edit his work. While reading his own stories out loud in order to record them, he realized that there were grammatical and punctuation problems. So he went back to his stories to edit them. The recording feature accomplished, in Marcel's case, much more than a simple engagement function, but a literacy one. Here is a log from an interaction with Spot.

```
SAGE : hello.my name is spot, what is yours?  
USER : T  
SAGE : can you tell me your age?  
USER : 19  
SAGE : do you have any problems?  
USER : I want a dog.  
SAGE : when I was a pup,I would be called names like "dot face" and  
"the black-and-white dog." I didn't like this so I went to a guidance  
councilor.She told me never to call the person names,but to talk to  
the person. It helped a lot. Has my story helped you with your  
problem?  
USER : no  
SAGE : I'm sorry that my story didn't work for you
```

Doug, the cartoon character, was created by Jessie. She wants to be a cartoon artist or a singer when she grows up and loves to watch cartoons on TV. Jessie drew her picture directly in the computer. Jessie worries when she gets into fights with her parents. She says that she has lots of problems with math, especially fractions, but she does better at reading and writing. She uses the computer at home to correspond through e-mail with pen-pals.

story of problem with working late

Will, I assume that you are working at MIT my creator told me that ok here is how you deal with it. Think about it. Your working at the 1 or 2 most important college in the here world! I am sure none of your family is truly disappointed there cheering for you in their hearts. Like I do

for Patti meets the girl I secretly admire well, this was good luck with your job just remember everyone is cheering for you, but if your child is complaining sit him/her down, and explain the importance of the job, and promise them some thing special when you have time to spend

Fig. 22: Jessie's designers' notebook

Jessie used her designer's notebook a lot and, as we asked her, not to erase what she wasn't going to use, but just cross it out. She wrote a dialogue between Doug and a user and wrote songs as well as stories for Doug to tell or sing. She never recorded the songs or wrote them in

the computer program. Interestingly enough, the songs that she wrote refer to issues that touch a chord with Jessie's feelings about her family:

"If your children are getting you down, first put yourself in their shoes and it will help you through; if your children like sports, go play a game with them and give them a privilege or two, all those things will help you through"

"If your family is your problem, if your family is your problem, just think how much you love them and think how much they did for you and got you through, Ohhhhh. Got to love' em ! Got to love'em ! yeah".

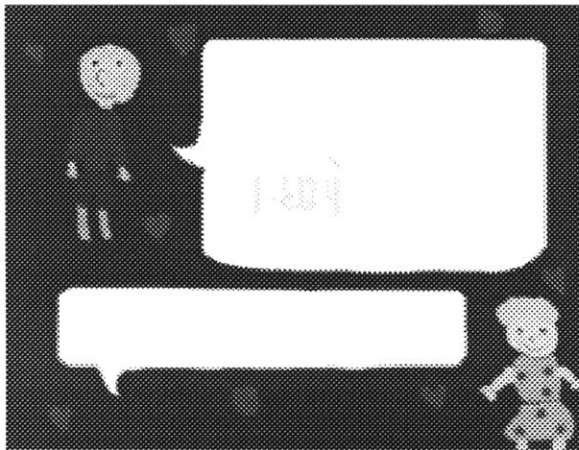


Fig. 23: Doug and his friend Patti

Jessie didn't include any of these songs or stories in her database. She wrote, directly in the computer, stories that happened to Doug and his friends in episodes of the cartoon series. However, Jessie used Doug as an "object to think with" about the problems that worried her and her family. For example, by writing the story shown above in her designer's notebook (fig.22), she

was able to decenter (see section 5.4) and put herself in her mom's shoes. However, for some reason, she decided not to let her, or any other member of her family, know about this story by excluding it from the database.

Following is a log from one of the last interactions Jessie had with Doug.

SAGE : Hi I am Doug and your name is ?
USER : Jessie Perez
SAGE : Do you have a problem that is bothering you if you do I can help you. What is bothering you?
USER :SCHOOL
SAGE : "DETENTION DETENTION" said Mr.Bone, the school's vice principal. He is probably the meanest thing alive thought all the kids of Bluffinton Middle School. There whole class was sitting in detention not because they did stuff wrong just because Mr.Bone didn't want the Beets (a music group playing at their school) because he didn't like their music (Mr. Bone is a yoddeler),but Doug thought detention was good because he got to sit next to Patti, the girl he secretly admired. Oh yes,I have to tell you how the whole thing started. Well, they all sent a note to the Beets asking them to come to their school.The Beets wrote back saying that they would be glad to come but Mr. Bone said "No" and threw them in Detention. So that's were we are now in the story. Doug hated school and wished he could quit,but he knew that would be wrong. So he stayed. He wished he could teach Mr. Bone a lesson and get over his hate of school. Suddenly the idea popped into his head to try to reason. Doug jumped from his seat if you let the Beets come to our school we'll let your yodoling group sing here. It was settled at that the Beets came to their school. I hope that I helped you with your problem,and if I didn't,well let's just hope I did. Did I?
USER : Yes
SAGE : that is great I am thrilled that I could help you with your problem so did you like this program?
USER : Yes I do very much
SAGE : well it is sad but true OK take a deep breath and get ready for this news this program of me is now over! will you do this again in your future ?
USER : Maybe

Figure 24 and 25 are drawings of children whose learning experiences are presented in chapter 5.

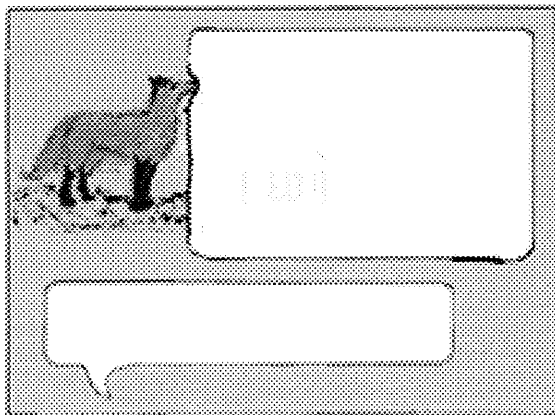


Fig 24: The Big Orange Fox

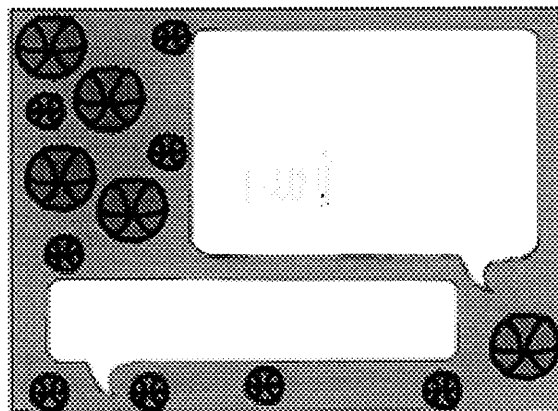
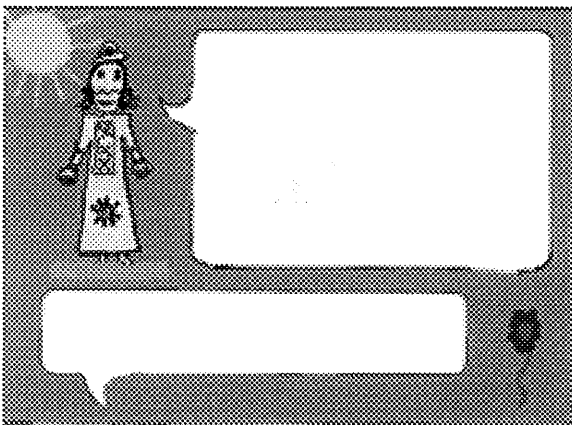


Fig.25: Tera Randof

The Big Orange Fox was created by Abi. The fox was drawn by an older friend of Abi's family. Tera Randof, the next character, was created by Tracy and is also described in those sections. Note in figure 25 that Tracy didn't draw a physical representation of Tera.

Mother Nature is a storyteller with a lot of personality created by Mischa, a fourth-grader who wants to be a teacher when she grows up and who loves math. Like Marcel, she drew her picture first, scanned it in and finally colored it in through Photoshop. She created the dialogue, or interaction, between Mother Nature and the user, whom she calls "person" in the designer's notebook first. Note Mischa's marks, in her sketch, when she foresees a branching in the interaction (see fig. 27).

Mischa created a very complex conversational structure that has two parallel structures, one for people who like to be in nature and one for people who do not. She decided to index her stories in the database according to different topics in nature: flowers, animals, rain, etc. She loved SAGE



because *"it is a program for you to make another program"* but she found it hard to *"type all the possibilities for what a person [user] might say"* ; in the future she wants to add more questions for the user, other than the *"yes or no type"* that she mostly has, and she would like to animate her character.

Fig. 26: Mother Nature

^{hello}
 S: I am Mother Nature. What is your name?
 Person: (seq (* any) (or "I'm" "I am" "is?") (* any))
 S: I am very old. April 7 is my birthday and I will be turning 3183! How old are you?
 Person: (seq (* any) (or "I'm" "I am" "is?") (seq (* digit) (* any)) age (seq (+ digit))) (* any))
 S: Well you're not too old honey! So, do you like to be in nature? I live in it!
 Person: (seq (* any) * yes (* any))
 Person: (seq (* any) * no (* any))
 S: Well that is very nice most people.
 S: Oh! Well that is too bad. I wish you did.

Fig. 27: Mischa's designer's notebook

SAGE : That is very nice! So have you ever done something good for nature?
 USER : yes
 SAGE : Oh, OK now I will tell you some stories. First I need you to tell me what your favorite thing in nature is because I might know a story about it!
 USER : animals
 SAGE : In school Julie had to list all the animals she could list not including insects or sea animals. Julie was a very creative girl and she thought it would be boring just listing them. She wanted to make up a creative story about them. So she asked her teacher if she could. Her teacher, Ms. Corty, said that was fine. As soon as Julie was home she started right on her story about animals. For each animal she wrote an adventure. Her first animal was the dog. Julie loved dogs! The story was about a little dog who could not talk nor make a sound. He thought he had the worst life but he really had the best a puppy could have! Even though he could not talk he had a special talent. He could dance better than any dog or human being. Now he knew this but no one else did. The little puppy thought dogs should not dance so he did dance in an alley where almost no one goes. But one day a super star searcher was doing his job and found the puppy. Soon the little dog was bigger than Michael Jackson! Julie finished the stories of the animals and brought it to school. She got an A+. Julie was so happy! The End!
 USER : thanks !
 SAGE : I hope you liked my story! I have to go and make it rain in Hong Kong! Good bye.
 USER : bye

Below is a log from an interaction with Mother Nature. The offered story, written by Mischa, reflects part of her experience during the workshop, while inventing stories for different things in nature.

SAGE : Hello, I'm Mother Nature. What is your name?
 USER : Mira
 SAGE : I am very old. I am already 3183! How old are you? Please tell me in numbers.
 USER : 24
 SAGE : Well you're not too old honey! So, do you like to be in nature? I live in it!
 USER : yes

In the post-interview, reflecting on her authoring experience, Mischa said: *"I learned that I really like nature, I didn't know that. And also my parents didn't expect me to choose Mother Nature*

because I usually don't mention that I like it. [...] By playing with the Big Orange Fox—which I really liked—I learned that kids can do lots of different stuff and that everybody makes different questions and tells different stories. But for me the most fun part was working on the computer and programming kind of a game for people to use. I liked creating what it might say and the questions and the structure and writing the stories and I learned that people can type anything and that you always have to be prepared because people might type not just "yes" or "no" but, for example "I guess so", so you have to use more branches and more stars and sequences ²¹."

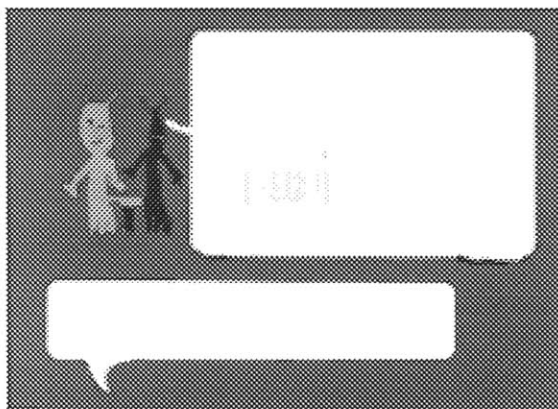


Fig 28: Waloompa, the alien

Waloompa, the alien, was created by Pauline who defines herself as a "compulsive reader" because she can't stop reading since she was four although her mom tells her to stop. She prefers legends, folk tales and myths that have magic. Pauline has a very well-thought-out concept of identity as "*who you are* ,

what people call you and what people think you are". Her character is an alien that asks for stories about earth and tells invented stories about its planet.

Below is a log of an interaction between a visitor to the workshops and Waloompa. Note that once Pauline learned how to use variables, she had her character add to the user-name the suffix "pa".

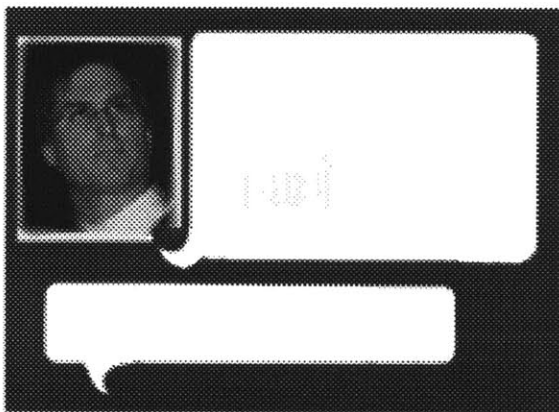
She did that in order to give to Waloompa an alien-like personality:

```
SAGE : Hi friendly being from earth. My name is Waloompa. What is yours?
USER : Nick
SAGE : Nice name Nickpa, but kind of hard to pronounce, isn't it. I am curious about you. Especially how old you are. How old are you?
USER : 24
SAGE : Interesting. 10 is a nice age. How long does your species live?
```

²¹Mischa refers to the syntax used to recognize user's input and match it against a template .

USER : To 100 if we're lucky
 SAGE : So you are not that old. I'm not very old either. I'm only 673. I'm very interested in your culture. Please will you tell me a short story from earth. Then I will tell you a story from my planet Hlgfhiblojcnilkcobelie
 USER : One time John Boy and I were down swimming in the creek, and John Boy came up out of the water all frightened. He said he'd seen a catfish down there that was so big it could swallow a man. I don't know if John Boy was telling the truth, but the next day, his hair was white as snow.
 SAGE : That was a good story Nickpa. This is My story. Once there was a mother who lived alone in the kijhag. One day she got up before the two suns rose. Soon she heard the sounds of hunting. Up came the zif they were chasing. She picked up the zif to save it from the hunters. "Up came a human!" It said "Did you see a zif run past here?" "No." she said truthfully. After the hunters left, the zif wumped out. It said "I am really a god. Thank you for saving me. I have been under a spell. The spell was broken when the human walked past me." And it disappeared in a cloud of smoke. Do you like my story?
 USER : yes
 SAGE : Then would you like me to tell you another good story?
 USER : no
 SAGE : Okay Nickpa. Goodbye for now.

After learning how the matching worked, Pauline decided that it wasn't good enough for her needs. So she avoided any type of matching by just asking the user to tell a story about his or her culture and responding with a story from planet "Hlgfhiblojcnilkcobelie". Pauline was very proud of her strategy because it would always work and she didn't have to worry about making a good match. Note that by the time Pauline came up with this solution, the rest of the children were having problems making a good match and selecting the right story keywords, nouns and verbs, to be used by the matching algorithm.



Mr. Smith was created by Seth, a fifth grader who wants to become a programmer when he grows up. Mr. Smith is a writer who tells book references —ISBN number included— and very short stories or poems according to the genre preferences of the user. The fact that Seth chose to offer book

Fig. 29: Mr. Smith, the writer

references might be related to the fact that his mother works in a library. Seth is familiar with content (such as ISBN numbers) that most of fifth graders are not. Following is a log of an interaction of Seth testing Mr. Smith:

```
SAGE : Hi. I'm Mr. Smith. Who are you?
USER : x
SAGE : Hello, x. I'm 49 years old. How old are you?
USER : -1
SAGE : So, x, you are 1 years old. What is your job?
USER : cvv
SAGE : Okay. You are a/an cvv. I am a writer. What kind of story
would you like to hear, x?
USER : adventure
SAGE Book Reference: From Alice To Ocean-Alone Across the
Outback. Photographed by Rick Smolan. With excerpts from Robyn
Davidson's best-selling `Tracks'.Published by: Viking Penguin Books
Australia Ltd.ISBN 0-760-84764-X. Did you like that story?
USER : No
SAGE : That is too bad. Maybe I gave you a reference to a book. If I
did, go to a library and borrow that book. Do you want to hear
another story, x ? "
USER : Nope
SAGE : Goodbye, x! Come again soon for more stories and book
references!
```

Seth, who has programming experience in QuickBasic, discovered how to use variables in SAGE and utilized them several times in his program in order to get user's age, name and profession. Seth was very aware of the fact that he was creating a "*simulated person*" and was the first child to actually interact with his storyteller to test it. While doing so, he would type testing sentences and even create test stories. Seth approached his project with a "scientific" style and, during the breaks, he would use the Macintosh graphing calculator for fun. Not surprisingly, his favorite classes at school are math and sciences. Although he said that he likes writing science fiction, he didn't write any story of his own. Furthermore, while copying one of the stories from his favorite book, he realized that it was too long so he wrote: "from here on the story has been condensed". However, his commitment to exact reproduction of reality was challenged when he took one of Pauline's science fiction stories and adapted it for his storyteller. He enjoyed best creating the conversational structure and he hoped to come back to program a pet assistant for Mr. Smith. Seth's approach to SAGE was different from that of other children, and the tool was able to

support his programming interests and his way of engaging, through editing other people's stories, with the world of expression and writing.

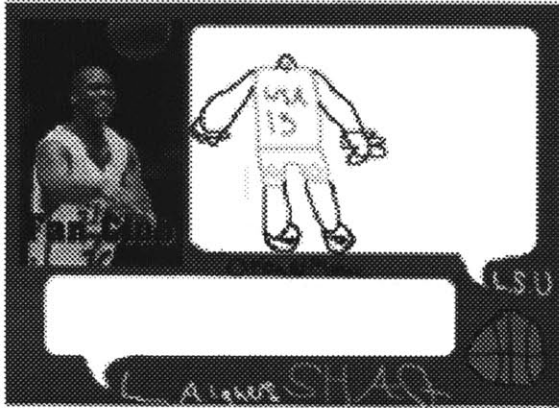


Fig. 30: Shaquille O'Neil

Shaquille O'Neil was created by Bernie and is presented in more detail in chapter 5. Bernie decided to scan in his favorite basketball player picture and then drew his own things inside and outside the talking balloons. When the text appears, the drawing inside the talking balloon disappears to allow an easier reading experience.

5. Analysis of learning experiences

“Rabbi Mendel said: ‘I became a Hasid because in the town where I lived there was an old man who told stories about zaddikim. He told what he knew, and I heard what I needed.’”

Menahem Mendel of Kotz

This chapter is organized in five sections and presents themes which emerged from the analysis of learning experiences of children using SAGE. These theme address the questions raised in chapter 4:

- Impact on storytelling: section 1 analyzes the learning continuum observed between interacting and building with SAGE and concludes that both modes of engaging enhance self-reflective personal storytelling. However, each of these modes supports different depth in the exploration of communication and identity issues.
- Impact on identity: section 5.2 shows how, by working on their own meaningful projects and being in control of their creations, children augment their self-esteem. Section 5.3 analyzes two cases in which SAGE was used as a tool to explore identity issues, by the children as well as by their parents.
- Impact on communication awareness: section 5.4 shows how, in an iterative design process, children were able to explore communicational breakdowns and storytelling bugs that exist in both real life and in interaction with the storytellers.
- Impact on modeling skills: section 5.5 analyzes the difficulties children found in working with abstract structures while programming their storytellers and suggests that children's knowledge about storytelling can be used to leverage their technological fluency.

5.1 The continuum between interacting and authoring

In regard to SAGE's goal to provide a computer environment to enhance children's expression of their personal stories, there is no difference observed in the level of engagement while interacting

with a storyteller already built or with one constructed by themselves. There is a continuum between the experience of interacting and authoring and suspension of disbelief is maintained. The major difference is the depth of reflection that both modes of engagement support. In the authoring mode, children were able to have a better understanding of the underlying computational mechanism and of the nature of communication. Since they were creating their own characters and databases of stories, they were also playing with different notions of self and creating or imitating the narrative voices they wanted or needed to hear. Piaget (1962) puts it this way: "Imitation is always a continuation of understanding, but in the direction of differentiation with respect to new models."

Ariel is a ten-year-old who knows how to program in Basic and loves to spend his free time with the computer and playing soccer. He only participated in the interacting experience. After sharing a personal story with the Hasidic rabbi (he told a problem related to his last soccer practice) he explained his intuitions about how the SAGE system works:

A: *When I typed in something, he'd basically repeat what I said, put an input like a k-string, and then he'd just print k-string. He will also look if there is a "yes" in it or a "no" or a "not really" and then respond. And then he would tell me a story from the library. It finds the story based on what you say. Like if you say I'm confused, that will probably do a story about some guy choosing one or the other option. And that's how it works, I think.*

F²²: *Even though you knew how it worked, you still liked it?*

A: *Yeah, I still like it. See, I wouldn't know all those stories personally, and if I needed to relate whatever I was thinking to something that I didn't know, like those stories, I'd do that.*

F: *Why ...*

A: *Well, I'd go to him, use the Sage partner. I mean, he knows the stories, not me. Even though I know what he does, I could not find a story in a book that exactly has what I want. And this, on the other hand, finds it faster than I can.*

²²"F" stands for facilitator.

Ariel's explanation of how the system works is pretty accurate, maybe because of his technological fluency (Papert & Resnick, 1995). However, despite this, Ariel was able to engage with the system in a meaningful way by telling a personal problem and reflecting on the comforting story offered to him.

The same level of engagement was observed in Miriam's interaction. As opposed to Ariel, Miriam is a novice computer user who plays a few computer games and only has taken typing classes at school. She shared with the Hasidic rabbi and the pet rabbit a story about how she would like to get along better with her mom, but she wasn't sure how the system worked.

F: So, how do you imagine it was working?

S: Um, I have no idea. I guess, well, sort of a talking bunny. I don't know. With the computer, he can see what I've written, so he can respond to it and process it. I don't know a lot about computers.

Miriam's explanation was less precise than Ariel's and probably the difference is due to her minimal experience with computers as well as her lack of technological fluency. However, her level of personal engagement with SAGE was as deep as Ariel's. Independently of their technological fluency, children who only interacted with SAGE had intuitions about the underlying computational mechanism. This was facilitated by the fact that most of the children are "experts" on communicational issues²³ and therefore were able to relate their experience interacting with SAGE to their experiences communicating with people.

For example, Miriam says: *"The computer is just answering the questions, because computers can do that, but with people you can never tell what they're going to say. And they always surprise you. Communication is talking and letting people know your feelings."* And Ariel, with more computer experience, says: *"I think we communicate by talking to each other and the computer*

²³Although children know how to communicate they do not always reflect about the nature of communication nor perform meta-communicational analysis.

communicates just by processing what you write and then finding something that relates. I think that in a program like SAGE, where it seems like someone's talking back to you, maybe there is something else."

During the workshops Tracy, a ten-year-old girl with no previous programming experience, created Tera Randof, a twelve-year-old female basketball player "*who will become a sport figure*" like the ones Tracy admires. Tracy knows how SAGE works, how Tera Randof responds on each occasion, when Tera will probably crash and which stories Tera can offer. She created the character and the conversational structure, as well as wrote all the stories in the database. However, the level of personal engagement while interacting with her own character is as high as Ariel's and Miriam's, who interacted with characters built by someone else. Tracy participated in the authoring experience of creating her own storyteller and, as shown in the above log, while interacting with her character, she still shared personal problems and worked hard in order to make connections between her personal situation and Tera's stories.

```
SAGE : Hello my name is Tera Randof. I am 12 years old. I love
basketball. I play center on my school team. Anyway enough about me
what's your name?
USER : My name is Tracy.
SAGE : As I told you I am 12. You are probably 10 or 11. Am I
right?
USER : Yes. I am 10.
SAGE : Wow! I guessed your age right? Great! I have a lot of
problems like wondering if my team is going to win the big
game or if I will mess it up for everyone. Please tell me a
problem you have.
USER : I am sad because my parents told me that we can't take my dog
on vacations with us, so I will miss him.
SAGE : Your problem reminded me of this story. Kerri is my best
friend. Kerri knows everything about me and I know everything about
her. Every Friday we sleep over each others houses. Switching
houses each week. This week it was at my house. I got the usual
snacks: popcorn, pizza, chips, soda, and candy. A few hours later
Kerri came by with her sleeping bag. You could tell she was in a bad
mood. I asked her to lighten up, and she snapped, "Fine." and left.
I was stunned. What was her problem? I waited the few minutes that
it took for her to walk home then called her. Her mom answered. I
asked to talk to Kerri. Her mom said Kerri doesn't feel like talking
to you right now.Kerri didn't talk to me in school for a month. Then
I got the horrible news: my mom got a great job in L.A. so we were
moving there! Kerri didn't even come over to say good-bye. I have
never seen or talked to her since. Maybe she wasn't really my best
```

friend. Did you like that story? Did you understand the moral of it? Please tell me what you think that story meant.
USER : You didn't see your friend ever again, but I will see my dog when we come back from vacation. I guess that is not that bad.
SAGE : Good job! I think you understand the story. Well I better go or I might miss basketball practice. I really liked talking to you. Hope to see you soon. See ya!
USER : Ok, bye!

Tracy is only one of the many cases in which I observed, by analyzing the logs of the interactions, that a deep knowledge of how the program works doesn't affect emotional engagement and sharing of a personal problem. At the same time, Tracy's knowledge of how SAGE works allowed her to reflect about the nature of communication in a deeper way and compare it with her intuitions about how people communicate with each other: *"A person already knows how to react to a question but the computer doesn't. You have to feed in information about what to say and that is like creating a mind and a personality. You have to feed in stories and a conversation structure and then create a code for matching people's possible answers but you have to make answers that would be logical and that can be understood. When you write stories you also have to write story values and verbs and nouns and it finds similar things in the conversation. When people communicate they take an experience they had or think of something that the other person might want to hear, a same sort of problem, something familiar or similar and they just tell it."*

SAGE, in both its interacting and authoring mode, enables self-reflection because it encourages children to tell their personal stories and make connections. A continuum was observed between both modes. However, in the authoring experience, children gained a sense of empowerment and control over their learning experience (see section 5.2). While creating their own storytellers, children benefited not only from self-reflection but also from exploring identity issues. Some children even built their storytellers as representations of themselves and created their own "helpers" or "listeners" (see section 5.3). In the interacting mode children started to wonder about the computation underlying SAGE, and to think about communication and storytelling. In the authoring mode they were able to explore and play with those notions in a deeper way (see section

5.4). At the same time they developed abstract thinking skills useful for programming as well as for making stories (see section 5.5).

5.2 Empowering children

Children who participated only in the interacting experience and therefore were not sure how the system worked, were more likely to blame themselves if a communicational breakdown occurred or the offered comforting story was not relevant to their situation. Children who participated in the authoring experience and therefore knew how SAGE works attributed, in the first place, communicational breakdowns to the “*stupid computer*” and not to themselves. As soon as those children became more fluent with the programming language they took control of their own creations and, when there was a bug, knew how to make the appropriate changes in the conversational structure.

Alice had the following conversation after interacting with the Hasidic rabbi:

F: Did you get a sense that the computer was understanding you?

A: Um, well when it said, how does this relate to your story and I told him, the rabbit sort of didn't really understand me and just told me another story.

F: And why do you think that happened?

A: Maybe because I didn't explain it clear enough for him-- probably just because I didn't explain it clear enough.

Alice didn't know that SAGE is not really understanding but is looking for matching user-inputs against a pattern template. What happened in her case is that, while explaining the connection, she didn't type the word “yes” or similar meaning, but directly wrote her understanding of the Hasidic story. Therefore the computer didn't recognize the expected input and offered her a second story as if she had not made connections with the first one. But Alice was not aware of this because she didn't participated in the authoring experience. For her, the program was a “black box”.

Children who participated in the authoring experience learned how to open the "black box" and were able to understand the computational processes as well as to debug their programs and conversational structures.

During the post-interview, when I asked children to choose a picture most like the experience of building their own storytellers, Abi chose a picture with a boy pushing a huge rock. *"I pushed a rock and then I got better and I got used to do it so I could push a little further. The rock was the beginning of the Big Orange Fox and then I got better and then I pushed far and far and it started to get easy for me. It is the first complicated program I ever made. And it is not like a program that you type something in and it says something to the person. This is very complicated because you have to think about what the user is going to say, altogether. You start thinking that you are like a user and how would you like to use the program and then you do it. Thinking in the place of the user was hard and also not being nervous that it will have bugs that you have to fix."* Note that in his recounting of the authoring experience, Abi brings important notions of user-centered design²⁴, as well as mentions the need of decentering (see section 5.4).

One of the more gratifying observations that children made during the workshops was that one of the best things was to create something from scratch. Tracy puts it this way: *"First there was nothing and then it was like creating the mind of a person and the computer was the body. But you are the mind because you create the personality that you want."* Jessie, the girl who had the hardest time understanding the authoring process and required the most help, said: *"Now I have a better idea of how programs are made and I can make one of my own. I started everything from scratch and at the beginning it was hard and confusing and I didn't understand but then it was fun and I was able to make Doug that lots of people like."*

²⁴For an interesting compilation of articles about software design with a user-centered method, see "Bringing Design to Software" by Terry Winograd.

The feeling expressed by both girls was shared by all eight children who participated in the authoring experience. Being in control of their own projects and "opening the black box" empowers children to think highly about themselves. And this, as constructionism points out, is a prerequisite for any successful learning experience.

5.3 Storytellers as presentations of the self

This section presents two cases, Abi's and Tracy's, in which self-awareness and identity explorations happened. Abi's use of SAGE to create his own storyteller, served for him as a catalyst to discover his fears and feelings; and for his parents, as a way to access Abi's inner world. Tracy's story shows a different way of using SAGE, also to explore notions of self in the present as well as in the future.

Abi is a fourth-grader whose parents come from Russia. Abi is bilingual and lives in the Boston area with his family. When he grows up he wants to be a physicist because he likes computers, math and science. Unlike all the other children who participated in the workshop, he said that he had never heard the word identity before, and after I explained its meaning he concluded: *"it is what is inside me, like being Jewish and American and having my relatives in Russia."*

During the individual pre-interview I asked Abi, as I asked all the children, personal questions like: "what worries you ?" "what makes you sad ?" "what do you do when you are sad and worry ?" "how do you know that you are feeling that way ?" (see appendix B). Abi told me that he worries because they tease him in class and because he needs glasses and is afraid that his bad eyesight will get worse. He talked non-stop for twenty minutes. When I told him that it was time for us to play with the computer, something that he was waiting for and was very excited about, he responded, to my surprise, like this: *"No, let's keep talking. I like these questions because I never think about this too much. I think that I know but I don't know that much. I want to know about myself, but I*

think I already know because if it is about myself I should already know but if I really get deep into it I don't really know. I have kind of an instinct to ask my mom for help but I don't even know that I am asking my mom and because of that I don't even mean that."

During the workshop Abi created The Big Orange Fox that would explicitly ask the user if she or he has religion problems, teasing problems, relative problems, learning and school problems. If the user responded positively, The Big Orange Fox would tell an appropriate story indexed under those categories. For example, below are two stories written by Abi. He indexed the first one in the database as friendship-problem, and the second one under religion-problem.

"There was a boy who was really rich who lived in the best house and got 3000 dollars per month for allowance but there was one thing he did not have and it was friends so he had a very bad life so one day he decided to live by himself getting his 3000 per month and living only a little better than normal people then he had a lot of friends but his friends did not understand how much money he wasted on necessary stuff so they thought he was spoiled and only played with him for money because he had to give 10 dollars per hour to whoever he played with and now he was sad because he had bad friends." (friendship-problem)

"There was once a boy who did not like his religion so he followed his family religion but when he was alone he secretly followed his religion but when his parents spotted him they cut off his finger and put him into a tiny dark box with spikes on all the sides but the bottom and left him there for 24 hours" (religion-problem)

Abi wrote twelve stories of this sort in his database and indexed all of them under different problems (see section 5.5). He is the child who created the most number of stories. This is extremely noteworthy considering that in the pre-interview Abi stated very clearly that he didn't like writing and he only liked to do it with a partner, not alone.

During the demonstration day, when Abi's parents came to play with The Big Orange Fox, they were surprised by the questions the character asked but even more by the stories it offered. While playing with other children's characters they noticed that Abi's was addressing in a direct way

personal problems as well as telling stories, that although fictional, were obviously expressions of fears and feelings.

During the post-interview, Abi said: "First of all I learned how to put myself in another place and pretend I am someone else; and I learned how hard it is because I was two people at the same time talking at each other. But really I talked to myself and I learned more about myself like what place am I right now. Because there was a time when I liked funny stories but now I like making sad stories. I think that people like me would really like my storyteller and people like Pauline would like Pauline's and people like Seth would like Seth's. My stories are sad, but if you want to hear a funny story you can play with Waloomba the alien. When you have a problem it is sad and that is why my stories are sad. But my family didn't like my stories too much because of that; but they learned on what place I am now, and I am in the sad stories."

After the workshop was over, Abi's mother contacted me. She was worried about the stories that Abi wrote. She didn't know that her son was thinking about those issues. As with many other kids of his age, Abi's recounting of the day is "Everything was fine." Abi's mother and I talked for a long time and we discussed the possibility of visiting a counselor. She also asked me for Abi's logs and transcriptions of the personal interviews. After consulting with Abi and receiving his authorization, I gave them to her.

Abi used SAGE to create a fictional representation of himself, for himself and for his parents. Through the creation of this character he was able to express feelings and fears that otherwise remained buried in everyday conversations. His parents also discovered, through The Big Orange Fox, a part of Abi's inner world. And Abi was happy that they had.

In the same way that Abi used SAGE to play with his fears and feelings, Tracy used it to represent herself in the future. The first day of the workshop she started to work on Tera Randof, a mixture

of her mom and her grandmother. She created the database by telling her mom's childhood stories. Tracy worked very fast and, on the first day of the workshop, she had mostly finished her project. The next week, due to technical problems in the saving of her character, she had to re-do the conversational structure. But this time she decided to build, under the same name and with the same stories, a younger girl who will become a sports figure. She says: *"Since I got the stories from my mom I had to changed them slightly, made them shorter with a more obvious value and moral. In the future I would like to work more on the conversation part and make it a little bit longer and ask more questions but also have Tera tell more about herself."* Tracy's role model was a female basketball player whom she admires and hopes to be like someday.

Tracy was the only child who didn't want to draw or scan a body or face for her character —she drew basketballs all over the screen. However, she distinguished herself by having created a very coherent and developed personality for Tera Randof. When Tera talks, it seems that is Tracy who is talking about herself, who is projecting one of the many possible ways in which she sees herself in the future.

5.4 Communication breakdowns and storytelling bugs

SAGE facilitates the exploration of notions of communication while observing conversational breakdowns in the interactions with the created characters. While using SAGE, the most frequently observed communicational breakdown was due to the children's difficulty to decenter and design interactions in which other people, different from themselves, can participate. The notion of decentering is linked to Piaget (1962) definition of infantile egocentrism conceived as a phenomenon of indifferentiation ("...confusion of his own point of view with that of others"). The iterative design experience, which involved programming and immediate testing with a real audience, gave children the opportunity to decenter and debug their conversational structures after observing other people's interactions. Communicational and computational bugs are not the same, and both become explicit with the use of SAGE in its authoring mode.

After interacting with the rabbit, pet assistant of the Hasidic rabbi, for the first time, Abi started wondering about the meaning of "understanding", a basic notion in exploring the world of communication and storytelling. *"I talked with a rabbit ,he asked me a problem I had, I answered him and in a strange way he answered me back. Well... He doesn't exactly answered me back, he told me stuff that might give me a little hint but he didn't exactly understand my problem. But it is annoying because it doesn't say what it is he doesn't understand; he just says that he doesn't understand. But I have no idea if he doesn't understand the words or how you say it or the meaning or why they [at school] tease me, who teases me or how they tease me. There is millions of people in the world and everybody has a very different way of talking but all of the ways can be understandable. I have no idea what the rabbit is not understanding."*

At this point of his experience, when he had only engaged in the interacting mode, Abi didn't know that he was proposing a paradox: in order for the rabbit to specify what it didn't understand, it first needed to understand user's input. During the authoring workshops Abi learned about the "computer way of understanding". In the case of SAGE, different from humans, by pattern matching of user input.

To create and understand pattern-matching was the most difficult and non-intuitive task for all the children and caused most of the computational bugs. And there are two reasons for this. First, the SAGE language itself becomes complex and too LISP-like for this task. Second, as mentioned above, children had difficulty decentering and pre-planning interactions for other people. Bernie's case is a good example of difficulty of decentering, understood as a failure to differentiate himself from the other potential users of his storyteller.

Bernie built Shaquille O'Neil and brought to the workshops pictures and books written by the famous basketball player. He adapted six of Shaquille's stories from a book and recorded them

with his own voice. He indexed them by typing values, not just keywords, such as "Good things can happen if you wait" and "If you have a plan then things are better than they seem." Bernie was taking programming classes with Logo in an after-school program. This knowledge allowed him to understand faster than other kids concepts such as variables and branching. He was able to quickly create a basic conversational structure that he wanted to test. However, when he tried to run Shaquille, he discovered that it wasn't working. The problem was that Bernie had not created any input pattern matching in the user-turn. He had typed the exact responses he wanted to give to Shaq.

While debugging, he realized this and decided to fix the problem. He created the pattern matching structures and copied the most complex ones, such as digit matching for recognizing user's age, from another character already built. He called me to showed me his new working version. Effectively, while Bernie interacted with Shaq, the program was responding adequately. I asked him to let me try it: the first thing that happened was that Shaq called me "Bernie", although he asked my name and I responded "Marina". Bernie immediately realized that he had hard-coded his name in all the responses and therefore showed understanding about pattern-matching of user inputs. The problem was not a computational bug, but a communicational bug. Bernie had not decentered himself, i.e. he had not created an experience for users different from himself.

A week later, when his parents came for the demonstration, Bernie had already fixed "the name problem", as he called it. However, when Shaq asked his dad: "I guess you are around 11, Am I right ?" and the response was "No, I am 45" , Shaq crashed. This time Bernie saw the problem immediately. He hadn't provide a branching to the age questions that contemplates the possibility of a "no". He went back to the authoring mode and added the branching to the conversational structure.

Bernie's situation was experienced by most of the children who also observed similar problems when their parents interacted with their characters. In general, there was a lack of branching, and the conversational structures were very linear (see fig. 31). Only after observing those interactions, did the children realize that they had to contemplate more possible responses. This discovery was facilitated by the iterative design process, meaning the loop of working on the computer and immediately debugging or trying results in the real world in an iterative process. Iterative design implies a reality-check with real users.

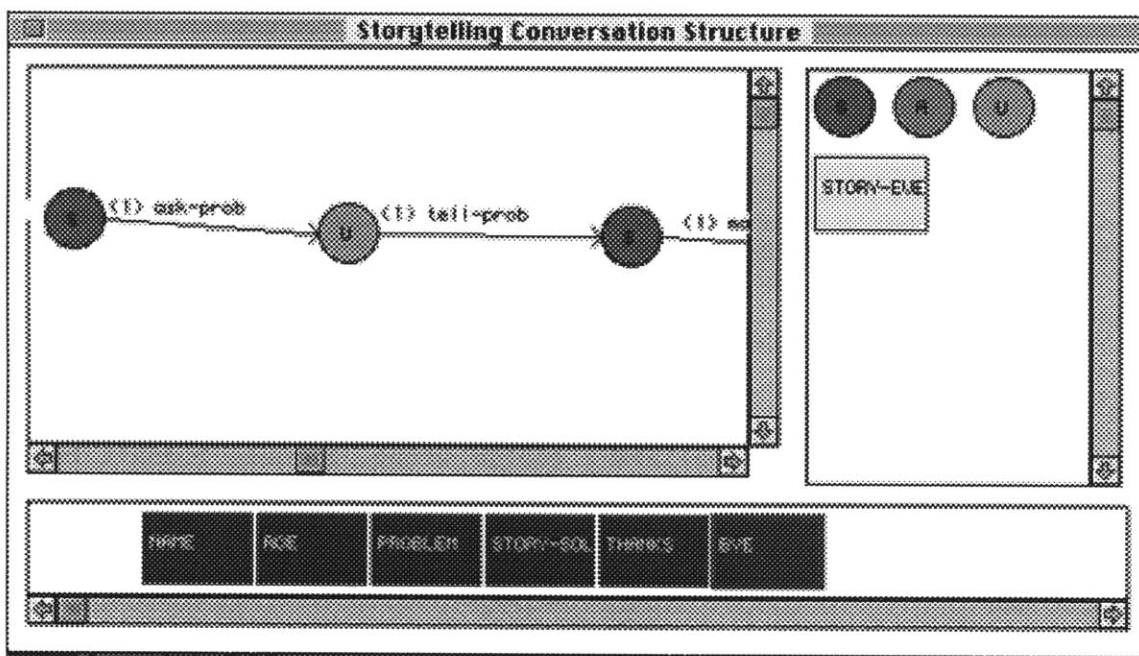


Fig 31 shows part of the linear conversation created by Bernie. There is no branching.

The power of iterative design is that it not only occurs while children are in front of the computer but also extends into their everyday communicational experiences. For example, Pauline, the author of *Waloomba the alien*, had the habit of never saying "good-bye" to the person who was video-taping the workshops, although she knew him and engaged in many conversations with him. I communicated this to Pauline and she responded *"You know what? Waloomba doesn't say "bye" either ? And "bye" is like "good-bye", I should put it in the macros* ²⁵. At the next meeting

²⁵Pauline refers to the match-macro templates that allow children to define template forms to be matched against user input.

she created a new storytelling part called "bye" with two turns: one in which the alien says "good-bye" to the user and one in which the user can respond farewell to the character.

Iterative design also helps the process of decentering. This process can be long and painful for some children and not a problem for others. From my observations I can say that children who had decentering problems also had more trouble creating a communicational structure in which the storyteller gives the floor to the user. In the following transcript of an interaction with the final version of Shaq we can see that the character doesn't prompt the user very clearly. The result is that most of the people who interacted with Shaq had to ask Bernie what they were supposed to do next.

SAGE : Hi. What's your name?
USER : My name is William.
SAGE : Hi, William. My name is Shaquille O'Neal. You can call me Shaq.
USER : Hi, Shaq [at this point the user asked Bernie, what he was supposed to say]
SAGE : You look about 11. Am I right ?
USER : No. I am not 11.
SAGE : Oh darn. I can't believe I got it wrong. I guess I don't know everything.
USER : I guess not. [the user, an adult, paused for a long time and looked at Bernie before responding]
SAGE : Well, William, do you have any problems you'd like to share with me?
USER : My son doesn't like school.
SAGE : When I was in school, I usually didn't get very good grades. I got into a lot of fights, and I usually didn't try very hard. I was the class clown. I played a lot of sports, and that was the main reason that I got bad grades. My parents talked to me and told me that I can't play sports unless I start getting better grades. This gave me a motivation to get good grades, since I love sports so much. From then on, I started getting better grades. My parents saw that I was improving, so they didn't take me out of sports. This taught me that if you have a motivation, it helps to do things easier. I hope this helped to solve your problem.
USER : Not really. But that was really interesting.
SAGE : Bye!
USER :

Decentering may be seen as one of the prerequisites for understanding communication as a process that involves at least two people. In SAGE, children need to decenter in order to design an

interaction by considering—in the conversational structure—the most likely answers which different users might give. The iterative design approach was a good way of helping children to decenter, and start thinking about the nature of communication, as Abi's and Pauline's cases show. Decentering and reflecting about communication enrich the experience of building with SAGE, as well as everyday lives. To realize that not everyone has the same things to say, and that people have different ways of communicating, is an important skill that makes happier interaction.

5.5 The difficulty of working with levels of abstraction

To create a representation or model of the structure of a conversation is not an easy task. With SAGE, it involves working with different levels of abstraction, such as what is actually said (scripts), when is it said (turn-taking) and why is it said (part of conversation). The part of conversation is the higher level of abstraction since it requires thinking and planning what is the goal of a particular chunk of the interaction that might include several turns, i.e. introducing oneself, comforting, etc.

Most of the children who participated in the workshop had troubles understanding what was a conversational part or a meta-level structure. Two examples show this. Jessie, who had the most difficulty with the concept, created the following conversational parts for her cartoon-character Doug: “greeting”, “user” “Doug” “Good”. From this meta-level structure it is clear that Jessie had problems understanding the difference between turn-taking and conversational parts. At the other extreme, Mischa, who created Mother Nature, one of the characters with the most complex conversational structure, also had a hard time at first understanding the concept but created two conversational parts “know-each-other” and “story-telling”. Children at both extremes of the learning continuum had trouble switching between levels of abstraction and, not only didn't find this high-level conversational parts helpful, but thought it disruptive to their their natural storytelling flow.

This finding was a surprise because most of the adults using SAGE to create their own characters, during IAP²⁶, found this abstract feature very helpful to a-priori organize the structure of their interactions. For example, Rabbi Grois, built by me, had the following conversational parts: “greetings” “sharing” “repeating” “comforting” “confirming” “good-bye”. However, children's difficulties shouldn't be so surprising because in the pre-interview, when they were asked to explain to a younger child how to tell a story, only one of them, Mischa used the notion of introduction, middle and end. The rest of the children responded with concrete examples like “I would tell him to think of something that he likes, real or not, and tell it.”

Switching between levels of abstractions is hard for children. For example, Wilensky (1993) expands on this in the mathematics education field. Among other research on metalinguistic studies (Hickmann, 1987; Gombert, 1992), children's use of SAGE suggests that the same difficulty is observed while working with storytelling. However, the concrete feature of turn-taking, with which they built their finite-states machines, was easily understood by almost all of the children. This is not a surprise; different studies show that children, especially girls, focus on who says what and when while playing their pretend-games (Cassell, 1997).

In SAGE, the pretend-game is a possible interaction between an imaginary user and the created character. For example, Pauline, the author of Waloomba the alien, who loved to work out loud used the turn-taking feature as follows: *“First Waloomba says hi and asks user's name and then the user responds and then Waloomba asks the user how old he or she is, and the user responds and Waloomba says “that is a nice age but how long does your species live?” and...”* This narration unfolded while Pauline placed the turns and communicational actions in the conversational structure window.

²⁶A workshop with MIT undergraduate and MIT staff was conducted, in collaboration with MIT Hillel, during the 1997 Independent Activity Period (IAP).

When I asked Pauline if she was programming while creating the conversational structure, she responded “no” in a very affirmative way. Her explanation was that she was telling stories and asking for stories and she wasn’t typing complicated programs. Most of the children responded in the same way to my question, except Bernie and Seth, who had more extensive programming experience. They thought for a long time and concluded that the only part in which they were programming was while creating the pattern-matching for user’s input. Bernie first said that he was creating something from scratch so he was programming the conversational structure, but Seth dissuaded him by saying “*No, because you were not typing*”. However, after re-thinking his response he added “*although I could sell Mr. Smith [his librarian character] like a program for others to get book references, so I guess I did a program*”.

Maybe due to a distorted view of programming, children in the workshops were not always able to recognize that they were creating formal representations and abstractions, and not only storytelling interactions, while dragging objects to the conversational structure window. Their notions of programming are still associated with a task that requires lots of typing. In the short period that the workshops lasted not all of them could positively realize that they were programming. However, they were creating finite-states machines composed of turns and communicational actions.

While creating storytelling structures and turn-taking machines, children explored concepts such as branching and structuring; while indexing the stories in the database they did exercises in knowledge representation. Abi’s case is one of the most noteworthy in this sense. Most of the children decided to index their stories either with keywords or with morals. However Abi chose categories that he called “problems”. After working hard he came up with the following categories: “religion-problems” “school-problems” “learning-problems” “relative-problems” “subject-problems” and “teasing-problems”. The Big Orange Fox asks, one by one, about all of the problems in this form: “Do you have any religion problem?” and so on. Abi's idea

was to have The Big Orange Fox tell a story relevant to the problem to which the user responded "yes".

In the first debugging session, while Seth was interacting with the fox, Abi found a main problem in his knowledge representation. Seth had "teasing problems" but also "school problems". Abi realized that some of his categories were "*inside the others*". For example teasing happened in school as did learning and subject problems. He was too proud of his category-based story indexing and he wanted to keep it. After lots of thinking he found an interesting solution that made him happy. After interviewing the user about all of the possible problems, The Big Orange Fox asks: "Take all the problems you said yes to, out of the ones I asked you. And please put them into the category you have most problems with out of these categories : school problems, learning problems, teasing problems, subject problems, friendship problems, religion problems ,and relative problems. Do only one category". From the point of view of the user and the interaction, this question posed by the character is very confusing. However, for Abi it was a good solution that allowed him to start thinking about powerful computational ideas such as "knowledge representation".

To create conversational structures as well as to categorize stories obliges children to reflect and work with levels of representation and abstractions. It introduces children to thinking in a different and more abstract way, without frightening them. This is especially useful for including girls in the world of technology (Cassell, 1997). The kind of experience that SAGE's authoring mode supports is a gateway to access the world of abstraction, pre-planning and structured thinking skills that are used in hard sciences as well as in storytelling.

6. Conclusions

"Now understand me well —it is provided in the essence of things that from any fruition of success, no matter what, shall come forth something to make a greater struggle necessary."

Walt Whitman

In this thesis I discussed the importance of technological tools especially designed to evoke children's self-reflection. I proposed personal storytelling as a gateway to access the inner world as well as to discuss notions of communication. I used constructionism as the basis for the educational goals of my work. By educational I mean, education about the inner world as well as the outer world.

I have designed, implemented and evaluated SAGE, a construction kit to create embodied interactive storytellers with which one converse. SAGE is comprised of three parts: 1) an interface module composed of a toy-output device and a computer-input device, 2) a computational module composed of a parser, WordNet and a matcher, and 3) a graphical programming language to model turn-taking storytelling. I conducted user studies to test interface preferences while engaging in the interacting mode, as well as workshops to explore children's authoring experiences.

The central contributions of my research articulated by the themes that emerged from the analysis of learning experiences are:

- The continuum between the interacting and the authoring mode in SAGE: From the self-reflection perspective, both experiences were successful. However, the authoring mode seemed to support deeper explorations of identity and communication as well as a bigger sense of empowerment and control over the learning experience.
- The creation of storytellers as projections of fears, feelings, interests and role-models: These projections allow the presentation of the self to ourselves as well as to others.

- The exploration of notions of communication while observing breakdowns: The iterative design experience supported this type of exploration by providing children with the opportunity to decenter and debug their system's conversational structures after observing other people's interactions with them.
- The use of children's knowledge about storytelling to leverage their technological fluency: Through the process of building their own storytellers, children developed modeling skills, abstract and structured thinking that are fundamental requirements for programming as well as for storytelling.

This thesis provides a conceptual and technological framework for designing and implementing technological tools for reflecting on the inner world as well as exploring communication issues. Both activities can also be done without technology, through mentoring with a good counselor or teacher. However, the use of computers enables a better exploratory depth as well as supports children's experiential learning while they are modeling and designing abstract conversational storytelling structures.

This thesis also provides a methodological framework for doing empirical research with children using technological tools for learning. The key is to design a meaningful activity that happens both with and without the computer, and not just a task to be accomplished with the technology. The endeavor is just beginning, and further research must be done in order to explore in depth each of the themes which have emerged from this work.

7. Future Work

"—Y hasta cuándo cree usted que podemos seguir en este ir y venir del carajo? — le preguntó. Florentino Ariza tenía la respuesta preparada desde hacía cincuenta y tres años, siete meses y once días con sus noches. —Toda la vida— dijo."

Gabriel García Marquez

El amor en los tiempos del cólera

In this chapter I organized the future directions of this work in three categories: Interface Design, Computation and Empirical Research. Each of these addresses problems with the actual system and proposes solutions.

7.1 Interface Design

The integration of a computer-input device and a toy-output device, through the narrative voice of two differentiated characters, is not an optimal solution to the split focus of user's attention.

Possible solutions would be:

- the use of a bigger toy which has a computer built in in its lap, therefore the focus of attention remains in the same area.
- the use of a speech recognition system. This solution seems the most attractive one because of the naturalness of interaction. However, the speech technology is not ready yet to be used in applications that must be speaker-independent with continuous speech recognition and no restrictions on vocabulary or grammar . A possible solution may be to use a speech recognition system with word-spotting capabilities. In the future, a microphone can be installed in the toy's ear in order to enable the toy to "listen" to the user's story.
- the use of a vision system so the toy can give non-verbal feedback according to the user's gestures and gaze, as well as sensing of haptic input so the toy can react to hugs, squeeze, etc.

7.2 Computation

- The current version of the SAGE programming language lacks a good intuitive visual model for matching patterns in user's input. Work needs to be done to create a visual library from which children can choose already built patterns as well as create their own. It is also important to think of a better way of visually representing the stories and their descriptors in the database.

- Future work can also be done to expand the limited domain of communicational situations that can be modeled with SAGE. The wise storyteller counseling through storytelling domain lends itself to this type of programming. However, other kinds of communicational situations may require the use of more complex procedures as well as computational linguistic devices to analyze discourse. In order to expand to new domains, the matching algorithm performance must be improved. In other scenarios, users may not want to make connections and personal interpretations but obtain precise information. Further work on story understanding might be useful to extract, not only keywords, but also narrative structures and content-based representations.

7.3 Empirical research

- The after-school workshops were a good first approach to conduct research while using SAGE authoring mode. However, it would be interesting to use SAGE within a pre-established community of learners, such as a school or an after-school program. This would offer the opportunity to do longitudinal observations and analysis.

- SAGE has the characteristics of a gender neutral technology which should support girls to become familiar with the world of technology and boys to become more comfortable with storytelling. However, gender-based empirical research needs to be done in order to test this hypothesis. An appropriate methodology should be defined to conduct gender-based studies.

8. References

- Austin, J. (1962) How to do things with words. Harvard University Press.
- Barthes, R.(1972) Mythologies. NY :The Noonday Press
- Bates, J.; Maes, P., and Hayes-Roth, B. (1995) AAAI Working Notes Spring Symposium: Interactive Story Systems: Plot and Character
- Bateson, G. (1972) Steps to an ecology of mind. NY: Chandler Publishing.
- Begel, A. (1997) Bongo: A Kid's Programming Environment for Creating Video Games on the Web. MIT MEng. Thesis.
- Benjamin, W. (1968) The storyteller. Illuminations. NY, Schocken Books.
- Bettelheim, B.(1976) The uses of enchantment : the meaning and importance of fairy tales. NY: Knopf.
- Borovoy, R. (1996) Genuine Object Oriented Programming. MIT Master's Thesis.
- Brooks, K. M. (1996) Do Story Agents Use Rocking Chairs ? The Theory and Implementation of One Model for Computational Narrative. In W. Hall & T.D.C. Little (Ed.), ACM Multimedia, pp 317-328, Boston, MA
- Bruckman, A. (1994) MOOSE Crossing: Construction, Community and Learning in a Networked Virtual World for Kids. Ph.D. dissertation.MIT, Cambridge, MA
- Bruner, J. (1986) "Two modes of Thought" in Actual Minds, possible worlds. Cambridge: Harvard Univ. Press.
- Campbell, J. (1988) The power of myth. NY: Doubleday.
- Cassell, J. (1997) "Storytelling as the nexus of change in the relationship between gender and technology" presentation at the Gender & Computer Games Conference "From Barbie to Mortal Kombat", April 5, 1997, MIT, Cambridge: MA.
- Cassell, J., C. Pelachaud, N.I. Badler, M. Steedman, B. Achorn, T. Becket, B. Douville, S. Prevost, M. Stone. (1994) "Animated Conversation: Rule-based Generation of Facial Expression,Gesture and Spoken Intonation for Multiple Conversational Agents" Siggraph'94, Orlando.
- Cassell, J. (1995) "The role of Gestures in stories as multiple participant frameworks". AAAI Spring Symposium: Interactive Story Systems,pp. 23-26.
- Colby, K. (1975) Artificial Paranoia: A computer Simulation of Paranoid Processes. NY: Pergamon Press.
- diSessa, A. & Abelson H.(1986) Boxer: A Reconstructible Computational Medium, Communications of the ACM, Vol. 29, No 9, September 1986, pp.859-868.

- Domeshek, E (1992) "Do the right thing: a component theory for indexing stories as social advice". ILS, Northwestern University.
- Don, A. (1990) "Narrative and the interface". The art of human-computer interface design. NY Addison Wesley.
- Druin, A. (1987) Building an alternative to the traditional computer terminal. MIT Master's Thesis.
- Erikson, E. H (1950) Childhood and Society. NY: Norton and company.
- Felsenstein, L. (1996) Interactive Rabbit. Interval Research Corp. Internal Technical Report.
- Geertz, C. (1973) The interpretation of cultures. NY: Basic Books.
- Glos, J. & Umaschi, M. (1997) "Once upon an object...Computationally-Augmented Toys for storytelling" ICCIMA '97, Australia.
- Gombert, J. E. (1992) Metalinguistic development. Chicago: Univ. of Chicago Press
- Hickman, M. (1987) Social and Functional Approaches to Language and Thought. NY: Academic Press.
- Harel, I. & Papert, S. (ed.)(1993) Constructionism. NJ:Ablex Publishing.
- Hooper, P. (1993) "They Have Their Own Thoughts: A story of Constructionist Learning in an Alternative African-Centered Community School" published in Constructionism in practice. Kafai & Resnick (ed.) NJ: Lawrence Erlbaum Associates.
- Ishii & Ullmer (1997) "Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms" Published in CHI'97 Proceedings, ACM, pg. 234-241
- Lakoff G. & M. Johnson (1980) Metaphors we live by. Chicago Press.
- Laurel, B. (1993) Computers as Theater. NY: Addison Wesley
- Linde, C. (1993) Life Stories. The creation of coherence. NY: Oxford University Press.
- Martin, F (1995) The Handy Board (<http://lcs.www.media.mit.edu/groups/el/projects/handy-board/>)
- Mauldin, M. (1994) "Chatterbots, TinyMuds & Turing Test" 12th Conference on AI.
- Miller, G., Beckwith R., Fellbaum C. ,Gross D. & Miller K. (1993) Introduction to WordNet.
- Miller, P.,Potts R., Fung, H., Hoogstra, L & Mintz J.(1990) Narrative practices and the social construction of self in childhood. American Ethnologist :17(2) pp. 292-311.
- Murray, J. (1991) Anatomy of a New Medium: Literary and Pedagogic Uses of Advanced Linguistic Computer Structures, Computers and the Humanities 25 pp. 1-14. Netherlands: Kluwer Academic Publishers.
- Papert, S. (1980) Mindstorms: Children, Computers and Powerful Ideas. NY: Basic Books.

- Papert, S (1987) Computer criticism vs. technocentric thinking. *Educational Researcher*, 16 (1), pp. 22-30
- Papert, S. (1993) *The Children's Machine: Rethinking school in the age of the computer*. NY: Basic Books.
- Papert, S. & Resnick, M. (1995) *Technological Fluency and the Representation of Knowledge*. Proposal to the National Science Foundation. MIT Media Laboratory. Cambridge, MA.
- Piaget, J. (1962) *Play, dreams and imitation in childhood*. NY: W.W. Norton & company
- Polanyi, L. (1989) *Telling the American Story*. Cambridge: MIT Press.
- Polkinghorne, D. (1988) *Narrative knowing and the Human Sciences*. State University of NY Press.
- Reddy, M. (1979), "The conduit metaphor" in *Metaphor & Thought* (ed. by A. Ortony). Cambridge University Press.
- Repenning, A. & Ambach, J (1996) *Visual AgentTalk: Anatomy of a Low Threshold, High Ceiling End User Programming Environment*. Univ. of Colorado at Boulder. Dept. of Computer Science.
- Resnick, M, Bruckman A, Martin, A. (1996) *Pianos not stereos: creating computational construction kits*. *Interactions*, Sept.-Oct. 1996, pp. 41-49.
- Resnick, M. (1994) *Turtles, Termites and Traffic Jams: Explorations in Massively Parallel Microworlds*. MIT Press.
- Rogers, C. (1961) *On becoming a person: A Therapist View of Psychotherapy*. Boston: Houghton Mifflin Company.
- Rosch E. & Mervis C. (1975) "Family Resemblance: studies in the internal structure of categories" in *Cognitive Psychology* 7, 573-605
- Rosen, S. (ed.) (1982) *My voice will go with you: The teaching tales of Milton H. Erickson*. NY: Norton.
- Sack, W. (1995) *The Holzer Machine*. <http://mu.www.media.mit.edu/people/wsack/holzer-machine.html>.
- SAGE Technical Report (1997) *Gesture & Narrative Language Group*. MIT Media Lab.
- Schachter-Shalomi, Z. (1991) *Spiritual Intimacy: a study on counseling in Hasidism*. NJ: Jason Aronson.
- Schank, R. & Riesbeck, C. (1981) *Inside Computer Understanding: Five Programs plus Miniatures*. NJ: Lawrence Elbaum.
- Schank, R. & Abelson R. (1995) *Knowledge and Memory: The Real Story*. *Advances in Social Cognition*, Volume VIII, pp. 1-85. NJ: Lawrence Elbaum.
- Suchman, L. (1987) *Plans and situated actions: the problem of human-machine communication*. NY: Cambridge University Press.

- Thórisson, K. (1996) Communicative Humanoids: A Computational Model of Psychosocial Dialogue Skills. MIT Ph.D. Thesis
- Turkle, S. (1984) *The Second Self: Computers and the Human Spirit*. NY: Basic Books.
- Turkle, S. (1995) *Life on the screen: Identity in the Age of the Internet*. NY: Simon & Schuster
- Umaschi, M. (1996 a) "Rabbi: exploring the inner world through stories." Published in AAAI 96 Proceedings, Students Abstracts, Volume II, MIT Press, pp. 1413
- Umaschi, M.(1996 b) "SAGE Storytellers: Learning about Identity, Language and Technology" in Proceedings of ICLS 96 , AACE, pp.526-531.
- Umaschi, M. (1997) "Soft Toys with Computer Hearts: Building Personal Storytelling Environments" Published in CHI'97 Proceedings, ACM, pp. 20-21
- Verón, E. (1987) *La semiosis social.Fragmentos de una teoría de la discursividad*.Buenos Aires: Gedisa
- Weizenbaum, J.(1976) *Computer power and human reason*. SF: Freeman & Cia.
- Wertsch, J. (1991) *Voices of the mind*. Cambridge: Harvard University Press
- Wigren, J. (1994) Narrative Completion in the Treatment of Trauma, *Psychotherapy*, vol.31, no.3.
- Wilensky, U. (1993) *Connected Mathematics_ Building Concrete Relationships with Mathematical Knowledge*. MIT Ph.D. dissertation.
- Winnicott, D. W. (1971) *Playing and Reality*. London: Tavistock Publications.
- Winograd, T & F. Flores (1986) *Understanding Computers and Cognition*. NY: Addison Wesley.
- Winograd, T. (1996) *Bringing Design to Software*. NY: Addison Wesley.

Appendix A: Questionnaires for interfaces user studies

Do you have a computer at home ? _____

If yes, what do you use it for ? _____

Name some of the games or applications that you use.

Do you have computer classes at school ? _____

If yes, what are they? _____

Do you like to read ? _____ If so, tell me about the last book or story that you read.

What do you like to do in your free time ?

Do you like to listen to stories about other people's personal experiences?

If so, what was the last story that you heard? _____

What was it about ? _____

Who told it to you? _____

Have you ever heard short stories that transmit a message or a moral ? _____

Where did you hear them? _____

What were they trying to teach you ? _____

Do you like talking about yourself? _____

Do you like telling stories about things that happened to you? _____

What was the last personal story that you told someone? _____

When something interesting happens to you, who do you share it with ? _____

Are there any stuffed animals at your house? _____

Do you play with them? _____

Do you have a favorite? If so, what is it? _____

Does it have a name? If so, what is it? _____

What is your favorite toy? _____

Why do you like it? _____

When do you play it? _____

Do you play with it alone or with someone else? _____

If you were able to make the toy of your dreams, how would it be? _____

Describe a situation in which you would use it. _____

Did you learn anything?

1
(not at all)

2

3

4

5
(a lot)

What did you learn? _____

How did you learn that? _____

How well did you understand the sage storyteller ?

1
(not well at all)

2

3

4

5
(extremely well)

If you could change the way the program works, what changes would you make?

What were you thinking about or imagining while you were interacting with the system ?

In the last part of the interview, the facilitator asks these questions - using her judgment on which apply and/or make sense for the child being interviewed.

Did the stories make sense to you? _____

What do you think about the three different ways for the computer to tell stories? _____

What are the differences between them? _____

What are the similarities? _____

Which did you like best? _____

Why? _____

How would you describe what you did today? _____

If you were given the tools to build your own storytellers, how would you do it? _____

What kinds of stories would you like to hear? _____

What kinds of stories from personal experience (things that happen to you) would you like to tell ?

Have you ever met a rabbi? _____

If so, when? _____

Was the rabbi a man or a woman? _____

If so, how did you meet him or her? _____

Did you talk with him or her? _____

If so, what did you talk about? _____

Have you ever heard similar stories to the ones that you heard today? _____

If so, when? _____

If so, where? _____

Who told them to you? _____

How were they similar? _____

What does "sage" mean ? _____

(If the child does not know what a sage is, the facilitator tells them at this point.)

Do you know any wise person, someone you respect, someone you like to get advice from?

Why is that person wise? _____

Where do you think you can find a wise person? _____

Why in that place? _____

Who tells you stories? _____

What kind of stories? _____

Who do you tell stories about things that happen to you or to your family? _____

Who listens to you when you have a problem or you want some advice? _____

Why do you trust that person? _____

What kinds of situations would you like to receive advice about? _____

From whom? _____

Appendix B: Questionnaires for authoring experience

Pre-study interview

PART I: Cultural Background, self-awareness, programming & storytelling interests

On the first meeting , pre-study interview, the child will orally respond to this questionnaire. The intention is to gain knowledge about child's cultural background, self-awareness, programming & storytelling interests. The interviewer can re-ask at any point or follow-up on interesting or not clear responses.

1.Programming & Storytelling Interests

Do you have a computer at home ? If yes, what do you use it for ? What games or applications do you like best ?

What is your favorite class at school ? Why ? _____

In which class you do better at school ? Why do you think this happens?

In which class you do worst at school ? Why do you think this happens?

What do you like to do in your free time ?

Do you like to listen to stories ? Why ? If so, what was the last story that you heard?

Do you like watching movies and TV ? What kinds of things do you like to watch ?Why ?

Do you like writing? If so, what kinds of things do you like to write ? What was the last thing you wrote ?

Do you use computers at school ? What for ?

Do you have computer programming classes? If so, do you like to program ? Why ? What kinds of things do you like to program ?

2.Cultural Background & Self Awareness

How do you describe your religion to your friends ?

How do you describe what culture you belong to ?

What groups does your family belong to ?

How do you describe your family to other people ?

Does your family have strong beliefs about anything ? What are they ?

Have you heard before the word "identity" ? What do you think it means ?

Do you have any friend that has a special cultural or religious identity ? How do you know so ? How do you think other people (that don't know him as well) can reach that conclusion ?

What would you like to be when you grow up ? Why ?

What things make you sad and worry ?

How do you know when you are sad ?

What do you do when you are sad ?

When you have a problem who do you get advice from ?

Why that person ?

What happens when you ask that person for help ?

What if that person is not available ? (repeat three times in order to get three answers)

PART II: Interaction with SAGE

First the child interacts with SAGE, combined version (15' approx.). Then he/she completes task 1: deciding which picture is most like interacting with SAGE, later the interview takes place.

PART III: Interacting is like...

After completing task 1 the child orally responds to this questionnaire. The intention is to promote self-reflection about their process of interacting with storytellers. The interviewer can re-ask at any point or follow-up on interesting or not clear responses.

Why did you choose that picture ? (referring to the chosen picture in task 1)

How would you describe to a friend what you just did ?

What was hard ? Why do you think that happened ?

What was easy ? Why do you think that happened ?

What did you learn by using SAGE ?

What were you doing with the computer ?

If you were going to build a new storyteller which one would you build ? Why ?

Which one of your friends would like to use this ? Why ?

In a month I am having a new workshop, can you suggest me a 4 or 5 sentences long advertisement that will convince other kids to come ?

PART IV: Notions of storytelling and communication found in SAGE

The child orally responds to this questionnaire. The intention is to explore child's notions of storytelling and communication. The interviewer can re-ask at any point or follow-up on interesting or not clear responses.

What were you telling to the computer ? (if the child mentions the word "story" ask : How do you know that those were stories?)

What was the computer telling back to you ? (if the child mentions the word "story" ask : How do you know that those were stories?)

What other ways of talking and interacting (other than telling stories) do people have ?

How would you explain to a younger child how to tell a story ?

How would you explain to a child when he/she can tell a story while having a conversation ?

How did you choose what story to tell to the computer ?

How do people decide what stories to tell to their friends ?

How do you think people know what to say ?

How do you think people know when to say it ?

How do you think people know how to respond to other people ?

PART V: Notions of programming and how SAGE works

The child orally responds to this questionnaire. The intention is to explore child's notions of computation and programming. The interviewer can re-ask at any point or follow-up on interesting or not clear responses.

How do you think the SAGE program works ?

What had in common the story that the computer told you with the one that you told to it ?

How would you describe what you imagine the computer did in order to find a story for you ?

How do you think the program knows what to say ?

How do you think the program knows when to say it ?

How do you think the program knows how to respond to you ?

What do you think are the differences between computer programs like this and people ?

PART VI: Deciding on a sage to build

The child orally responds to this questionnaire. The intention is to promote self-reflection about their process of choosing a meaningful storyteller to build. The interviewer can re-ask at any point or follow-up on interesting or not clear responses.

Do you know anyone you respect, someone you like to get advice from?

What kind of storyteller would you like to build ? Why ?

Would it be someone you know or someone that you imagine from scratch ?

How would you describe that storyteller ?

What kind of stories this storyteller would tell ?

Where can you find those stories ?

Would other children like to talk with this storyteller, do you think ? Why ?

Which other children would like to talk with this storyteller? Why ?

Post-study interview

PART I: Building with SAGE

The child completes task 2: deciding which picture is most like building, designing and programming with SAGE, later the interview takes place.

PART II: Designing/programming is like...

After completing task 2 the child will orally respond to this questionnaire. The intention is to promote self-reflection about their process of building their storytellers and to observe the differences/progresses with their responses during the first meeting. The interviewer can re-ask at any point or follow-up on interesting or not clear responses.

Why did you choose that picture ? (referring to the chosen picture in task 2)

How would you describe to a friend what you did during the workshop ?

How would you describe to a friend how you decided which storyteller to build ?

How would you describe to a friend the process of building a storyteller ?

What was hard ? Why do you think that happened ?

What was easy ? Why do you think that happened ?

If you were going to build a new storyteller which one would you build ? Why ?

What would you change in the way you did it before ?

What did you learn by using SAGE ?

What were you doing with the computer ?

Which one of your friends would like to use SAGE ? Why ?

In a month I am having a new workshop, can you suggest me a 4 or 5 sentences long advertisement that will convince other kids to come ?

PART III: Interacting with SAGE

The child interacts again with Rabbi Grois. The intention is to observe if there are differences in the qualities of the stories kids tell and to observe if something triggers their curiosity. The interviewer can re-ask at any point or follow-up on interesting or not clear responses.

PART IV: Notions of storytelling and communication found in SAGE

The child orally responds to this questionnaire. The intention is to explore child's notions of storytelling and communication after the process of building their own storytellers. The interviewer can re-ask at any point or follow-up on interesting or not clear responses.

What other ways of talking and interacting (other than telling stories) people have ?

How would you explain to a younger child how to write or tell a story ?

How would you explain to that same child when he/she can tell a story in a conversation situation ?

While interacting with the storyteller you built, how did you decide which stories to tell ?

How do people decide what stories to tell to their friends ?

How do you think people know what to say ?

How do you think people know when to say it ?

How do you think people know how to respond to other people ?

PART V: Notions of programming and how SAGE works

The child orally responds to this questionnaire. The intention is to explore child's notions of computation and programming after using SAGE. The interviewer can re-ask at any point or follow-up on interesting or not clear responses.

How does your storyteller work ?

What did you want to do that you couldn't ?

How did you choose which stories to put in the data-base ?

How did you decide which stories will be given by the computer to the user and when ?

How would you describe what the computer did in order to find a relevant story for the user ?

How do you think the program knows what to say to the user?

How do you think the program knows when to say it ?

How do you think the program knows how to respond to the user ?

What do you think are the differences between computer programs like this and people ?

PART VI: Cultural Background & Self Awareness

What would you like to be when you grow up ? Why ?

What did you like better, to interact with the storyteller you built or with someone's else ? Why ?

Is there any particular storyteller you wish someone has built ?

With what kind of storyteller do you think your parents would like to interact with ? Why ?

What kinds of stories they would like to hear ?

With what kind of storyteller do you think your best friend would like to interact with ? Why ?

What kinds of stories he/she would like to hear ?

Did you learn something about yourself while creating your storyteller ?

And by having other people interact with your storyteller ?

And by interacting with other storytellers ?

What new things do you think your family learned about yourself when they interacted with your storyteller ?

