Lali: Exploring a Tangible Interface for Augmented Play for Preschoolers

Hester Bruikman  Annemiek van Drunen  He Huang  Vanessa Vakili
User System Interaction, Faculty of Industrial Design
Technical University of Eindhoven
Den Dolech 2, 5612 AZ Eindhoven
Tel: +31 40 247 5230
{h.s.d.bruikman, a.v.drunen, h.huang, v.vakili} @tue.nl

ABSTRACT
This paper outlines the exploration of a tangible user interface for unstructured play, in which a physical plush toy is used to remotely control an augmented digital representation of itself. Preschool users were profiled and an initial prototype was built and evaluated using a co-discovery exploration. It was observed that the children enjoyed playing with the toy, and that the children over 2 years of age understood the remote coupling of the physical and digital representation.

Categories and Subject Descriptors
K.3.1 Computer Uses in Education: Computer-assisted instruction (CAI); J.7 Computers in Other Systems: Command and control; J.4 Social and Behavioral Science: Psychology and Sociology; B.4.3 Interconnections (subsystems): Interfaces

General Terms

Keywords
Tangible interfaces, preschool children, play, co-discovery, user centered.

1. INTRODUCTION
Our objective is to create a tangible, remote-controlled virtual character for children under five years of age. We have three aims: to create a toy for unstructured play that will increase fun; to observe the reaction of preschoolers to real-virtual coupling; and most importantly, to support imagination using an augmented play approach.

Developing virtually augmented play is important, because it allows the visualization of imaginary possibilities beyond what exists. Imagination generally develops at the age of 2 [5][6], meaning that preschool-age children have a special need for support. Imagination in preschoolers is positively correlated with healthy emotional, social and cognitive development[1]. Note that our work is focused on unstructured play.

Several TUI designs exist for children over 5 years old, while for younger ages, designs and accommodating studies are scarce. Designing for preschoolers presents unique challenges for interactive systems, due to their underdeveloped motor abilities, and to a mental and emotional development in flux. By contrast, designing for children over 5 involves very different mental models.

2. RELATED WORK
2.1 Tangible Interfaces
Ishii and Ulmer [7] developed a framework for the characterization of tangible user interfaces. They define three key characteristics of TUIs. These include that physical, manipulable objects that 1) are coupled to the digital information model, 2) include mechanisms for interactive control, and 3) are perceptually coupled to the digital representations of information.

Xu, Read, Mazzone, MacFarlane and Brown [10] state that TUIs are a natural way for children to interact with digital media, due to their early development of the ability to manipulate physical objects. We note a few related examples of tangible interfaces here.

PlayPals [8], developed by the MIT media lab, focuses specifically on unstructured play. PlayPals are dolls whose movements can be synchronized and controlled remotely by children, and be used as two-way communication devices. It was tested with children between 5 and 8 years. Another example, SenToy [9], is a doll that can control the emotions of a character in a computer game through gestural manipulation. SenToy was not designed specifically for children, however the authors noted that it was especially liked by children who tested it (the youngest being 9 years old).

The remainder of this paper describes a concept, Lali, for a TUI with associative mapping of multiple interface elements, each statically bound to a digital action. Like PlayPals, it is for the augmentation of play with a familiar kind of toy, in this case a plush toy and for children under 5 years of age. The concept is novel in that it is a system for unstructured play that targets preschool-age children.

3. DESIGN REQUIREMENTS
Our design methodology was user centered. User profiling and personas were used to gain insight into the targeted user group. The design process has thus far followed one iteration, including an evaluation, which will be discussed in the following section.

3.1 Children and their Abilities
A review of the literature was done to find out the abilities, goals and characteristics of children from 0 to 4 years. One of the main conclusions of this short review was that children within this age group differ a lot and change fast.
The cognitive development model of Piaget was used [5]. In this model, four stages of cognitive development are discriminated. The first Stage is the sensorimotor stage, for children form 0 to 2 years, in which children interact directly with the world through actions and senses. In this stage they are not able yet to use symbols. In the next stage, children learn to use fantasy and “imagine” things without carrying them out. This later stage runs from approximately 2 to 7 years of age. The stage model consists of more stages, but the above described were the ones relevant for the age group we used. According to the stage model, children in the former stage will probably not understand the mapping between the plush toy and the screen. Nevertheless it has to be mentioned that Piaget also emphasized that the division between ages in the different stages is not strict. [5]. Therefore the mapping was tested with preschoolers falling into both groups.

3.2 User requirements
Apart from the mapping, other aspects of our product design have to be taken into account, like possibilities, goals, preferences and limitations of our focus group. We summarize several basic user requirements based on user analysis, personas and the described research of Piaget. Firstly, a toy for children should provide a soft tangible interface as is attractive to most children. Second, the size of the toy should be suitable to children of different ages under 5 years old and the points of contact and control should also be easy to reach and manipulate. Third, children are sensitive to color and sound, so sound should be used as feedback which can attract children’s attention. Fourth, all the functions should be understandable for children and the virtual manifestations should contain both physical actions and emotional expressions.

4. PROTOTYPE DESIGN
4.1 Construction
The initial prototype for the Lali interface consists of a plush toy, fitted with internal sensors. For the proof-of-concept phase, the plush toy is linked by an umbilical cord to a PC (though ideally it would be wirelessly linked). “Plug-and-play” Phidget sensors were used to control the virtual Lali animation, built in Adobe CS3 Flash. The two representations are shown in Figure 1.

4.2 Functionality
Children could control the virtual Lali by touching and squeezing corresponding parts of the physical Lali. Effort was made to take advantage of natural affordances to create associative mapping between the physical and digital representations.

All functions are statically mapped to the physical sensors. Touching physical Lali’s nose causes the virtual Lali to sneeze. Hugging Lali causes blushing, and above a certain pressure threshold hearts would radiate from the body. Squeezing the paws makes the arms rotate upward independently. Furthermore, touching a sensor in physical Lali’s navel alternately causes the virtual Lali to burp or giggle. Virtual Lali’s tail was animated to wag automatically every 25 seconds.

5. EVALUATION
This section describes the evaluation of the prototype described above. The evaluation was meant to validate a proof of concept.

5.1 Method
To gain insight into the cognitive process of our users while playing with the toy we used a “co-discovery” approach. Co-discovery is aimed at stimulating children to provide verbal comments which are more natural than the commonly used "thinking aloud" method in usability studies, [2]. Three techniques were used to collect data. Firstly, we used the "this-and-that" interviewing technique to give the children a chance to demonstrate an activity while discussing [3]. The "This-and-that" technique was implemented by asking the children who the virtual image was and who the physical toy was. Secondly, we used observation as a technique to register non-verbal behavior. The observers noted all the verbal comments and non-verbal behaviors made by the children and their supervisors. Finally, all actions the children executed with the plush toy were logged. For this we used Camtasia Studio version 4.0.

5.1.1 Participants
The user group with whom we conducted a user test consisted of 14 children with an age range between 10 months and 42 months. The children were all recruited through a daycare centre located in The Netherlands.

5.1.2 Setup
The testing was held at an area of the daycare centre that was familiar to the children. Physical Lali was connected to a laptop PC with a long USB cable. Virtual Lali was projected on a white wall near the children. Speakers were used for sound projection. Three daycare supervisors and a facilitator were present to stimulate explorative behavior because of regulations of the daycare centre. Two experimenters were present to observe behavior.

5.1.3 Procedure
The user test took place in the morning after a short introduction round. Children took turns playing with Lali. Taking notice of children’s short attention span [4], we limited the overall duration of the session to 45 minutes, during which children were asked questions in a stimulating manner by the facilitator
or the supervisors. Experimenters wrapped up by asking the children questions according to the "this-and-that" method.

5.2 Results
We used conventional coding to structure the observations that were made during the experiment. For this we used QSR International’s Nvivo 8, which is qualitative data analysis software [11]. Figure 2 and Figure 3 provide the coded frequencies of various actions and animation activations by the children, respectively. Besides these categories, many more interactions took place that are not discussed here for brevity. It was found that 6 of the 14 children showed an understanding of the mapping between physical and virtual representation.

The observations on understanding the mapping can be better interpreted through the following remarks by the supervisors:

- Some of the children understood the mapping between the toy and the screen; mostly the older ones (3 and above)
- Some younger ones will probably understand more of the mapping when they have more time to interact with Lali.
- The smallest children (under 2.5 years) seemed to not understand the mapping or only understood parts. Nonetheless, they still enjoyed hugging Lali and watching the screen when others played with Lali.

The last statement is supported by the number of times the observation was coded that children ‘just hold’ Lali.

Below is a graph of comparative frequencies with which children activated Lali’s sensor controls.

![Figure 3. Relative frequencies of video activations.](image)

6. Discussion
In this section we discuss our preliminary questions and answers on how children would respond to Lali based on the observations made during the user test.

Our first question was twofold. Namely, whether children would look for the sensor location and map this location to the virtual Lali. Some children seemed to understand that they had to touch a certain spot on Lali to evoke activation by the virtual Lali and actively searched for these locations. Coding from observations and comments by supervisors indicated that this understanding existed for the children over 3 years old. However, there was almost an equal amount of signs that no understanding existed for the younger children. Still, this did not seem to influence the amount of fun these children had playing with and holding the plush toy.

Another question was whether Lali would become a status symbol. Although the facilitator and supervisors made sure each child got their turn in discovering Lali, sometimes a child claimed Lali when it was not his or her turn or wanted to keep it as long as possible. Also, the other children were paying a lot of attention to the one holding Lali, which made Lali indeed some kind of status symbol.

Furthermore, we were interested to learn to what extent the children would find Lali fun, as indicated by laughing, smiling, hugging, or repeatedly touching the same sensor. As coded from the observational data, they were laughing and smiling a lot, and also imitated the sneezing sound many times. Also, the children repeatedly pointed towards the screen where Lali was shown. The most used function was the nose pressing (sneeze activation). The sensor on the nose was easy to reach and the children liked the sneeze sound and behavior of Lali. The latter was concluded from the fact that they started laughing and imitating Lali when he made the sneezing sound. In addition, the hugging function seemed popular and children started laughing, smiling and pointing when they saw the hearts. The popularity of this function cannot be derived from the Camtasia data. The appropriate sensor was less accessible, hence the radiating hearts were not activated as frequently as one would expect based on the observations of enjoyment when this sensor was activated. Also, the tail and the legs were observed to be popular, but no sensors were embedded there. The observed activation attempts
of especially the tail provides a valuable lesson to embed sensors in easy to grab parts of the toy.

In general observations and density in the logging data indicate that the children enjoyed playing with Lali, although, it is difficult to establish the cause of results, especially concerning likeability. Results could be caused by the tangible interface, the likeability of the plush toy, the likeability of the virtual representation of the toy, or the variation in the day-to-day schedule the children are accustomed to and the attention received simply by participating in a study. These and other psychological effects could affect the observed responses of the children while participating in a study [3].

7. CONCLUSION
Lali is a new design for a tangible interface allowing for augmented play. It combines a plush toy hooked up with various sensors and a flash animation responding to the respective sensors in an engaging way. The evaluation showed that children above 3 years old quickly understood the concept and enjoyed playing with it. Lali is to the best of our knowledge one of the first systems of its kind, targeting preschool children.

8. REFERENCES