Pop Goes The Cell Phone

Asynchronous Messaging for Preschoolers

Hayes Raffle[1], Rafael Ballagas[1], Glenda Revelle[2], Koichi Mori[1], Hiroshi Horii[1], Chris Paretti[1], Mirjana Spasojevic[1]

[1] Nokia Research Center
955 Page Mill Rd, Palo Alto CA 94306
hayes.raffle | tico.ballagas | koichi.mori | hiroshi.horii | chris.paretti | mirjana.spasojevic @nokia.com

[2] Human Environmental Sciences
University of Arkansas
Fayetteville, AR 72701
grevelle@uark.edu

Abstract

This paper outlines a series of experiments to develop asynchronous messaging systems for preschool aged children. Three unique systems build on a foundational design called *Toaster*, a jack-in-the box toy with embedded mobile phone that allows children to playfully take and share electronic media. *Orange Toaster* allows children to create and share self-portraits; *Family Toast* allows children to browse family photos with physical tokens, and shares their self-portrait reactions with remote family members; *Play with Elmo* allows children and distant adults to asynchronously share playful video messages. Observations with over 30 children suggest that asynchronous photographic or video messaging with very young children is possible. The results of these studies indicate specific guidelines including (1) children's UI's need to be playful and immediate (2) UI designs for children should create the "here and now" feel of real-time interaction, and (3) adults' UI's must provide emotionally meaningful feedback from children to engage adult users.

Author Keywords

Children, family communication, messaging, mobile

ACM Classification Keywords

H.5.2. Information interfaces; H.4.3. Communications Applications.

General Terms

Design, Human Factors

INTRODUCTION

According to the AARP, more than half of grandparents in the US are more than 200 miles from their grandchildren today [6]. While recent research has shown that video conferencing tools help families achieve a sense of togetherness over a distance [1, 12], a common challenge for long-distance families is managing schedules and logistics of getting together around their computers at the same time. This is especially true when families span multiple time zones, and schedules do not conveniently overlap [4]. While asynchronous messaging has become a dominant communication mode for teens and adults to address varied schedules, we find little evidence of asynchronous media that are usable by very young [16]. We believe this is due lack of age-appropriate designs of asynchronous media for children, and propose that there is a great need for better communication tools for very young children.

Figure 1. Children make self-portraits with Orange Toaster

Preschool children obviously can not use text messaging or other text-based forms of asynchronous communication. Being able to see and hear a long-distance relative talking (as in Skype communication) is an important first step, but there is reason to believe that asynchronous video-based communication will present challenges for communicating with children ages three and under. Anecdotal evidence suggests that young children who view videos made of their relatives at some point in the past do not understand the concept of time-shifting with regard to personal communication. In addition, there is research-based evidence [20] that very young children have difficulty

understanding information presented via screen-based media, unless it contains real-time contingent social interaction. It has been argued [13] that the social brain "gates" young children's acquisition of information in situations that lack contingent social interaction.

Asynchronous messages have different properties than synchronous communication, presenting new opportunities for creating family connections. Recordings can serve as mementos, helping us remember ones we love, and can be accessed even when our loved ones are not available. Asynchronous communication can help manage some of the 'presentation work' in family communication [1], allowing tighter control of how we are portrayed in messages, including the ability to discard and recreate messages before sending. Also, the ability to record once and playback many messages at once can help address asymmetric energy and enthusiasm across generations including children's need for repetition [9], but adult's low tolerance for it. Clearly, meaningful asynchronous media could help long-distance families, but how can such tools be crafted so that they are accessible and useful to the young and old?

This project is investigating new ways to help long-distance families have a stronger sense of togetherness with young children. We address several interrelated challenges. First, how may we create accessible interfaces for young children? In this work, we have looked to physical toy-like devices to make interactions engaging and intuitive for young children. Second, how can we meet the needs and abilities of adult loved ones who wish to connect with distant toddlers? We take the approach to help an adult *play* with children who are far away.

RELATED WORK

Although children as young as 14 months have been observed holding toy telephones and engaging in pretend "conversations" [9] and preschoolers imitate the structure of telephone conversations in their pretend play with toy telephones [10], engaging in actual communication with another person over the telephone remains quite challenging for children throughout the preschool years.

A number of researchers have found that young children's telephone conversations contain numerous examples of "egocentric speech." Piaget [17] classified young children's speech as "egocentric" when the child fails to take the point of view of the listener into account. Cameron and Lee [3] found that 3 and 4 year olds used non-specific referential terms and omitted necessary details (for example saying "move this one this way" instead of "move the red piece to the left") significantly more often than older children in a telephone-based referential communication task. Likewise, Warren and Tate [21] found that three and four year olds gave egocentric responses ("look at this," pointing, nodding or shaking head without saying anything) significantly more often than older children in spontaneous telephone conversations with an adult relative.

In addition to the quality of their telephone-based communication, young children's telephone conversations are very difficult to sustain for any length of time. Warren and Tate [21] found that preschool children's telephone conversations were significantly shorter than their face-to-face conversations: the average phone conversation contained about 42 child utterances whereas face-to-face interactions averaged 88 child utterances.

Ballagas et. al have argued that video is more developmentally appropriate for the young, and that it is a more naturally shareable medium than audio-only tools like telephone [2]. Recent work in family communications has sought to use communication tools to help long-distance families have a greater sense of connection and togetherness over a distance. Following recent social trends in Skype use among families [1], these projects have used video chat tools to help the young and old connect over a distance.

One approach has been to create ways to play together over a distance. Family Story Play and StoryVisit are systems for "connected reading" that combine video chat and children's books. The inclusion of books led to a 5x increase in video chat times for families with very young children, compared to Skype use alone [18, 19] because children and adults had a playful activity to share. Other explorations of play over video chat include lightweight games as in "Video Play" [8]. Games touched on classic play patterns such as book reading, dress up, pretend play, and charades. Their approach of open-ended play, informed by classic play patterns, is consistent with ours. We are trying to apply such play patterns to asynchronous media.

Commercial tools are emerging in this space. AStoryBeforeBed.com[1] allows adults to record a video of themselves reading an e-book to a child. The recording is sent via email to the far-away child, who can watch the book and video come to life on their parent's computer or iPad. The system provides no means for the child to communicate their responses or reactions to the adult reader, thus providing only a one-way path for communication. A similar recording approach is provided by Hallmark's recordable story books that allow a reader to embed their voice into a paper story book[2]. As the child turns the pages, they hear the recordings of the adult reader bring the book to life. We view such products as recording devices, not communication devices. Our goal is to provide long distance families with bidirectional communication tools that provide emotional richness to both children and adults.

Following trends in Tangibles, recent explorations into using toys as proxies for children's communication have begun to explore how children's play can scaffold distance communication that might otherwise seem to abstract for children to manage [7]. Several investigations into domestic

[1] http://www.astorybeforebed.com

[2] www.hallmark.com/online/in-stores/recordable-storybooks

appliances [11, 14] have addressed family messaging. Our work builds on this trend by exploring asynchronous communication-through-play.

Finally, we must note that our work stands in contrast to the proliferation of children's apps on smartphones [5] which generally ignore the communication potential of smartphones, and treat them as toys or gaming devices. Toy accessories are emerging in the market that follow these toy and game like trends, merely giving physical form to some of the experiences. While such toys are valuable for play and learning, they do not fully unlock smartphone technologies' potential. Our work seeks to contribute to an understanding of how to use apps, services and playful devices to create meaningful communication experiences for very young children to connect with loved ones who are far away.

TOASTER

This paper focuses on "Toaster," a Jack-In-The-Box toy that is intended retain the classic play patterns of traditional children's toys and use a parent's cell phone to add communication functions that can help create bridges between young children and distant family members. In Toaster, a smartphone provides multimedia features (such as photo recording and display, video recording and display, music playing, and networking) and a networked pop-up toy

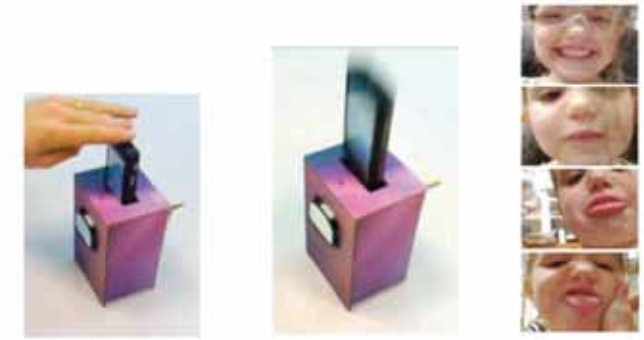

Figure 2. Children's self-portraits appear when the phone pops up. Photos are shared with family members on Flickr.

transforms the phone into a tangible interface with an intuitive UI for young children. The concept leverages the notion that future networked toys can incorporate a parent's cell phone - perhaps the parent's personal device, or perhaps a retired phone that was given a new life in the child's hands – to empower children to engage in new learning and communication activities.

We have made several assumptions in our designs:

- Smart phones have the capacity for communication, which can be made accessible to children through play.
- Classic toy designs can be leveraged to engage and scaffold young children's communicative play.
- Children's and adults' UI's may need to be different (asymmetric) so that they can each leverage the skills, interests and abilities of the targeted user.

In general, all Toaster designs have the same play mechanic: a phone is inserted into the Toaster and pressed down. A spring-loaded plunger latches and causes the phone to start playing *Pop Goes the Weasel*. While depressed, the phone performs multimedia functions, such as taking a photo, cueing up a video, or displaying an image on screen. With the classic *Pop Goes the Weasel* end-of-song timing, the phone pops up displaying the media. Children's images or performances with the device are automatically captured by a front-facing camera on the phone, and are then shared with distant loved ones (Figure 2).

Three unique Toaster designs explore asynchronous communication in different ways. The designs all share the same play mechanics outlined above, but explore communications in different ways. We present our experiments chronologically, and will organize each subsection in the same way: brief motivation, design process, user testing, and remarks. Since each prototype in our iterative design process included individual pilot studies, we present these with the three individual system descriptions. Following this report of our designs, the next section will explore common findings and learnings.

Experiment 1: Orange Toaster — playing with self-portraits

With the *Orange Toaster*, a child can insert the phone into the toaster, press the phone down, and watch it pop back up with their self-portrait on it (Figure 1). Unbeknownst to the children, the toaster also has a secret communication function: the photos, once captured, are emailed to their parent, and posted on the parent's account of a secure photo sharing website. While the children play, the parents get digital surprises to enjoy, to delight in their children's happy and silly faces (Figure 1, 2).

Iterative design

Prototypes, with embedded Bluetooth Arduino boards were fitted with actuators and spring-loaded pistons. The lightweight springs that came with the toys were replaced with stronger springs to create a more dramatic effect, causing the phone to literally fly out of the toaster and fall on the floor when it was released. This amplified response was met with delight by researchers, and the prototype was taken to the home of one of the researchers for an initial trial test with his children.

The children, ages 2 and 4, immediately understood the concept, and quickly took to arguing about whose turn it was to use it. The children created a number of photos of themselves and of the world around them, and seemed to have trouble putting their faces in front of the camera at the right time. Amidst one argument about whose turn it was, one child put her face over the phone as it was released. The large force of the phone caused her to get hurt and cry. This first prototype passed the test for playfulness and repeated use at the target ages, but it failed the "mom test" when the child's cries led to its banishment from the home.

Refining the UI

A second prototype included two main modifications: a lighter weight spring was used for child safety. Several changes were made to help children bring their faces into view: the slot for the phone was angled back about 15 degrees so that the camera would face up towards a child's face when it was placed on a table. Also, a spring loaded mirror was attached to the piston mechanism so that as a child pressed the phone down, the mirror would slide up and provide a convenient place for children to "preview" what might be captured by the camera.

In subsequent trials, this second prototype was met with greater success, although children still had trouble getting their faces into view all the time. We explored using a wide angle lens on the front-facing camera, and with using a wide-angle mirror that allowed children to see their whole faces at once (the original mirror, which was small, only allowed them to see a portion of their face). Both approaches improved the results, with the wide angle mirror having the largest effect.

This modified version was initially tested with 6 different children ages 2-6 and was met with overwhelmingly positive enthusiasm. Children would usually create dozens of images of themselves in a single sitting, repeatedly making silly faces and exploring the possibilities of the device. For example, in one session in March 2009, three children ages 2, 5, and 7 played with the device in their home one evening. The children created 51 images of themselves in a 15 minute period, averaging a new photo every 17 seconds. Considering that the song plays for 7 seconds, and it takes about 2 additional seconds for the phone to be pressed down and pop up, this reveals a dwell time of about 8 seconds between each use. For three children playing concurrently, where the times include negotiation for turn-taking, these data show an intense interest on part of the children.

Following these initial trials, the device was taken to a local laboratory preschool and used actively by about 28 children ages 3-4, in two 1 hour sessions over the course of 2 days (Figure 3). The device was arranged in a small music room available to the children, and presented by the teachers as a new activity the children could explore if they wished. Teachers invited children into the room in singles or groups to play with the toy, and three researchers (one from the preschool, two from our team) facilitated the study and video recorded children's interactions. For privacy reasons, the children's portraits were not recorded by the toaster device, and video records of the study are represented in this paper with illustrations.

All children seemed to find the Orange Toaster to be accessible and salient. The "jack in the box" mechanic was generally irresistible for all children, and the device seemed to capture the sense of suspense and surprise that is characteristic of the classic toys. Technology added a new dimension for the children - seeing their self-portraits,

Figure 3. In a lab preschool, groups of children explore the *Orange Toaster* and *Play With Elmo* Toaster.

children's faces would erupt with delight, causing them often to compete to push down the phone again. One group of three children pushed the phone down about 17 times before making room to share with another group of children. Seeing themselves encouraged children to make different silly faces for the machine, often sticking out tongues, pulling a friend into the frame, or turning the whole Toaster to point in a different direction.

Colin (4) confirmed with his teacher that he understood how the Orange Toaster worked:

Colin: *See, it takes a picture. yeah, this one takes a picture.*
Teacher: *Who is it taking a picture of, Colin?*
Colin: *Whoever it's facing at.*

later, the teacher prompts, "how could we make it so it takes a picture of Jake?" Colin turns the toaster towards Jacob, and pushes the phone down. Then he instructs, "Jacob, look at the mirror." He clearly understands the workings of the toaster and enjoys using it, returning the second day to play again. Jacob, 4, spent a total of over 30 minutes interacting with the Toasters, and was one of the "lead users" in the study.

This larger trial confirmed the general age-appropriateness of the design for three and four year olds. While the communication aspects of the system were disabled for this trial, the results confirm the system's success for the children. To address the toy's role as a communication system, we addressed the overall feedback loop with two families.

The parent-sharing features of Toaster have been initially used and explored by two researchers who had young children themselves. Every time a child created a photo, it was shared with their parents via email and posted to the parent's Flickr account.

In general, the parents were delighted to find the photos of their children, sometimes arriving unexpectedly. Similar to other family photos, the best ones were shared with friends

and repeatedly admired. While a child's repeated photos of random objects would likely become a nuisance, the photos of one's children were met with more lenience. Only 1 in every 10 photos was worth keeping, but these two (admittedly non-representative) parents reported that the emotional content that they carried gave an overall positive feeling about the children and the system at large.

Remarks

With Toaster we created a tangible interface for children to create self-portraits, and secretly shared these images with loved ones via email and Flickr. The Orange Toaster invited repeated use for children ages 2-6. The combination of tangibility with its coincident input and output, simple mechanic, and playful suspense allowed it to retain much of the classic play pattern of a Jack in the Box, with the added dimension of allowing children to capture and laugh at images of themselves, and integrating communications functions with basic children's play. While Orange Toaster confirmed a successful toy and means for children to create and share playful portraits with their loved ones, it did little to support children's awareness of their distant family members. As a messaging system, it was a one-way street for children to create and share content with adults (the opposite of current commercial tools like recordable story books). It was successful in part, but did not reach our goals to support complete bidirectional communications.

Experiment 2: Family Toast — Tangible play with the family photo album

Family Toast (Figure 4) experiments with a bi-directional photo sharing system: First, parents filled the phone with photos from the family photo album. Then, children placed one of several physical tokens, labeled with a printed photo of a loved one, in the toaster. When the phone was pushed down, it would load an image of that person, play a song, and pop up, displaying the family member's photo to the child. The child user's face was then photographed and their portrait was secretly sent to the child's parent and loved one who was shown in the picture, as a form of "reply" to the adult's photo "message."

Figure 4. Three-year-old places a token into *Family Toast* to see pictures of her father with *Family Toast.*

In order to allow children to choose among a catalog of images, we incorporated a magnetic token reader from a refrigerator magnet toy so that children could insert tokens into the toaster to change which photo is displayed, and with whom the child is “connecting.” Faces of familiar family members (parents, grandparents, siblings, aunts, and the children themselves) were printed and individually attached to different physical tokens, with one face on each token. Family photos were preloaded on the phone in individual file folders each corresponding to a family member, and the tokens caused a photo from the corresponding file folder to be used during play. One token was also fitted with a wide-angle mirror, so that the children could make the toaster create self-portraits as they could with the Orange Toaster.

Trial

The prototype was preloaded with photos from one researcher's family and tested with his children about 6 times in a home environment.

The children enjoyed the new toaster and spent quite a bit of time exchanging tokens, pressing them like buttons, and pushing the phone down to make photos appear on the phone. The mirror token was quickly grasped and met with the delight found in the previous designs. The photo-album mechanism was met with surprise ("look, Grandpa") and seemed to be clearly understood by both children, ages 2 and 4. The children talked about the photos, remembering when and where they happened, with the older sibling at times recalling the story for her younger sister. Children especially liked seeing pictures that showed them with their family members. In fact, seeing their own faces delighted them in this system as well: the token that was used most pictured the children themselves, as the children relished in pushing the phone down to see old photographs of each other. This device seemed to be an intuitive and playful way for the children to view their family's digital photo album.

The children enjoyed both creating self-portraits and browsing family photos, but seemed to delight more in taking self-portraits than in seeing photos of others. Comments from the children revealed one reason: the photo albums included in the prototype contained limited sets of photos. "Oh, we saw that one already" remarked the 4 year old, after seeing a photo repeat. Larger photo sets would likely interest the children for longer times, especially if the photos pictured the children themselves.

Children's reactions to these photos were photographed by the phone and emailed to the children's parent, who screened and then forwarded the most interesting images to the family members whose images had been viewed. While children were interested in browsing photos of others, their reactions that were photographed by the phone were less interesting for the parent to view. Without the visual feedback of the mirror and self-portrait game that invited silly faces, the photos of the children looking at family photos generally paled in comparison to those from the self-portraits in which they were rewarded for their silly faces and other visual performances. Despite the diminished appeal of the images, the researcher at times noted that stories children told to each other about the photos were interesting. Witnessing children's simple but interesting stories about the photos inspired the question, could recorded video provide richer snapshots of the children

a. Grandparent records a message with Elmo (touch your nose!) on their computer.

b. Child watches the recorded messages with Toaster and is invited to play along.

c. Grandparent receives movies of the child playing with the messages on a web page.

Figure 5. Communication Loop, *Play With Elmo*

thinking of their family while in their youngest years? We addressed this question in our next design.

Remarks

Family Toast explores more complete feedback loops for family communication. The tangible tokens, mapped to family members' identities, were intuitive and direct for children, who quickly understood the use of the tokens. The suspense and playfulness of the Toaster design continued to capture children's attention in Family Toast, and we discovered an effective way for children to browse their digital family photo album. In capturing children's responses to viewing the photos, we introduced a complete feedback loop that allowed adults to see children's responses to their photos. The children's stories with each other about the photos inspired us to experiment with video messaging in *Play with Elmo.*

Experiment 3: Play with Elmo

In seeking richer ways for long-distance families and friends to share asynchronous messages with very young children and each other, we repeatedly returned to questions related to video messaging. In *Play with Elmo*, we explored ways to extend the Toaster to share video messages back and forth between young children and distant adults, and to create a system which would give distant family members a new way to participate in children's lives, and be present in children's minds.

In somewhat of a reversal of the design of the Orange Toaster, in *Play with Elmo* the adults are the initial performers: adults record movies on a website using their computer, and when the children play with the toy, the movies (which are automatically downloaded to the phone for the kids to watch) play and invite children to play along. When children watch the movies, their reactions and performances are automatically recorded and sent back to the grown-up who created the movie. Elmo is there to facilitate the whole exchange, getting grown-ups to do age-appropriate performances to engage young children, and setting the stage for distant parties to "do things together."

One initial and central question concerned how to scaffold adults to "play" with children who were far away. With asynchronous video messaging, we felt challenged to help adults to create age-appropriate videos for children, and to engage children in dramatic play in front of the smartphone's camera that would inspire adults to create more movies. In our observations of adults engaging in video chat with young children [1], we saw that distant adults often did not know (or perhaps forgot) how to be silly and engaging to a very young child. This would clearly be even more difficult if the adult did not have the immediate feedback of the child's laughter and other reactions to their play, which are available with synchronous media like video chat. To address this, we thought about how a playful character like Sesame Street's Elmo could facilitate play between the young and old. Elmo, we believed, could give the adult the permission and prompting they needed to do silly things in front of a video camera. A movie that included both Elmo and the child's loved one might also be more powerful for the child than a movie of the grown-up alone; Elmo, we hoped, would amplify an adult's message and help engage young children and prompt them to respond and react in dramatic ways.

In the first prototype, Elmo footage was mocked-up and tested with two researchers and their children. The scripting of Elmo followed two schemes: in one scheme, the parent and Elmo took turns, using cinematic cuts between Elmo and the adult. Elmo, full screen: *Guess what Dad looks like when he's angry*. Cut to parent, making an angry face. Cut back to Elmo: *Can you show Elmo YOUR angry face? (pause 5 seconds, waiting for child's reaction…) Oooohhhh, that's scary, hahaha.* In the other scheme, Elmo and the parent play together, e.g. singing a song. Elmo would prompt the adult, *Let's sing the ABC's!* and the adult would record themselves singing. The child would see the movie begin with Elmo full frame and see Elmo shrink into a corner frame while the grown-up appeared full frame.

This version was mocked up with the Toaster and shared with 8 children ages 3-7 to test its basic appeal to young children. The children included both researchers' families and their friends. Since the viewfinder visual feedback was absent from the Toaster during Play with Elmo, a wide-

angle lens was fitted to the phone's camera. Children at all ages 3-7 responded positively to the concept, happily playing along with Elmo and the grown-up. However, the children who had a close personal connection to the adult in the video were most engaged with the toy, repeatedly playing along with singing, making silly faces, and pretending to act like different animals (as Elmo directed). Children enjoyed mirroring the actions of the adult in the video, e.g. coming closer to the camera in the ABC's when a father did. Also, children especially enjoyed taking the phone out of the Toaster and cradling it in their hands while watching the movies.

Children's "responses," secretly recorded, were uploaded to the parents' Flickr pages and sent to their email accounts. Some of the videos were appreciated by the parents. The relative success of this early prototype led to the development of a fully functional prototype that could be more easily customized by with a range of children and adults.

A fully functional prototype

In creating a fully-functional prototype, we addressed generalizing the content, producing high quality Elmo footage, and making a system with a bi-directional feedback loop. A key design decision was to base all scripting on the scheme of "playing together" in the here and now, which simplified the scripting and UI design. The hypothesis was that if Elmo encouraged the child and adult by saying "let's all do it together" (whether it was singing, making silly faces, playing "Elmo Says," dancing, or pretending to be different animals) that the child might be more likely to experience the interaction as if it were happening in real time, and thus be more likely to comprehend and engage.

Our goal was to create a system simple enough that a non-technical grandparent could use it comfortably. In general, the older people we interviewed were open to the concept. One grandparent who was interviewed about the concept reacted positively: "You know, my kids grew up with Sesame Street. So I see the Muppets as kind of teachers. I think it would be fun to make a video with Elmo."

We recreated the video mail service with a web front-end (Figure 5) using Flash Media Server to handle video recording, and a variety of web, telephony, and server technologies to transcode and transport the videos to and from the website and the child's phone. Basic UI design followed simple webmail applications. In introducing video, a number of technical hurdles arose, including eliminating echo from adults' recordings with Elmo, automatic compositing of Elmo and the adult's video, and transcoding videos between mobile and web platforms.

This final prototype system paired the adult's web site with the child's smartphone and Toaster device in real time, using a combination of technologies. When an adult created a new video, the child's phone would immediately be notified via a push message, and the phone would download the composited video of the adult and Elmo playing together. When the child pushed the phone into the Toaster, they would hear it play its song, and then see it pop up with the adult and Elmo doing something together - with Elmo facing the child and inviting her to play along. The child's reactions would be automatically recorded and sent back to the adult, ready to view in the video inbox. Videos would accumulate on the child's phone and could be watched repeatedly. Adults could flag favorite video replies and save them as keepsakes, a sort of a "digital family connection." The system allowed for near real-time feedback loops and bi-directional communication, and leveraged the strengths of both the desktop and Toaster technologies.

A study at a laboratory preschool

In order to get a broad perspective on children's reactions to the prototypes, we brought *Play with Elmo* to a laboratory preschool with 3 and 4-year-old children, alongside the Orange Toaster (Figure 3). About 28 children actively played with the two versions of the toy in two one-hour sessions over a period of two days, with 14 children playing each day and 2-3 children overlapping between the two days. To simulate the potential for *Play with Elmo* to create a sense of interpersonal connections between a child and remote adult, one of the preschool teachers made eight recordings of himself with Elmo which the children experienced in their classroom. We hoped that his students would recognize him in the movies. To simulate "distance" we asked that this teacher be in a visually separate location from the study (this was possible due to the large size of this classroom). The sessions were videotaped, but children's reactions were not recorded in order to comply with the school's privacy requirements. Images from our video records are depicted as illustrations in this paper.

All children seemed to understand the basic mechanic of the toy once they tried it, although children seemed unaware that the phone was recording their reactions while watching the videos. Initially, children who were familiar with Elmo recognized his distinctive face and voice, but some children did not initially recognize teacher Todd, the adult who was in the video. However, other times children did recognize both people: "Who's that?" asked a teacher. "Teacher TODD!" says Claire. The teacher follows, "Who is that? Do

Figure 6. Two boys race to push down the phone.

you know the name of that person?" Claire: "It's Elmo!". Teacher: "Do you know Elmo?" Claire, "Uh huh. he's a funny dog," reacting to Elmo's recent performance pretending to be a dog. Then Claire plays for a while. A new girl sees it and comments, "Elmoooooo." The teacher offers, "Claire, can you show Jane how it works?" Both girls laugh together at it, and later wave and yell HI to both Elmo and teacher Todd.

All children seemed to understand the basic workings of the toy. Once children began to recognize the content, they played with the toy in different ways, depending on their interests and social dynamics. One group of competitive boys watched the videos about 10 times and then began to ignore them, just racing to press the phone down after it popped up (doing this for about 30 presses) (Figure 6). This group was determined to compete: several times, six small hands would land on the phone at once, pressing it down into the Toaster. Other children were more apt to take turns. A group of girls patiently watched the videos about 10 times together, not wanting to stop, enjoying the repetition of the movies and occasionally softly singing or playing along with the videos. Another boy spent about 3 minutes exploring the spring mechanism of the toy, trying to understand how it worked.

Children had different reactions to Elmo. In general, Elmo made children smile, which was one desired effect. In Elmo's script, he asked children to "sing together" or "play together." One child followed Elmo's prompts and sang "Twinkle Twinkle Little Star" with him and Todd, but often children did not "play along" with Elmo as he asked them too. This finding was in contrast to earlier findings with in-home studies, so it may have been due to the social dynamics and noisy preschool environment. Children seemed to enjoy Elmo with a suspension of disbelief that is characteristic of television content, and quite different from the performances invited by the Orange Toaster. One child asked "is Elmo real?," a question that may have been prompted by the image of his familiar teacher appearing in the movie along side Elmo.

In-Situ Home Trial

Following the preschool study, teacher Todd, who participated in recording for the preschool, brought *Play With Elmo* home to try with his own daughters ages, 20 months and 6 years. This study, which is ongoing, gives some insight into how the system may be used by actual families in-situ.

Initial responses have been positive, yet full of critical and useful feedback. First, Todd reported that his 1 year old seems not to understand the device completely. He explained that she is still somewhat confused about television and screen-based content in general, and is probably too young to fully grasp the system. However, playing with the toy and watching the videos in her father's lap did make her smile and laugh, and she did recognize both Elmo and her father in the videos. Her six-year-old sister developed a more complete appreciation for the system: the father showed her how her performances with the phone were being recorded and uploaded to the website, which they viewed together on their home computer. After seeing several instances of her recordings, she began to "play along" with Elmo and her father more deliberately, pretending to be a frog, or singing "Twinkle Twinkle Little Star" along with the video of her father and Elmo. This evidence supports design modifications that reveal the recording functions to children more directly, possibly with real-time visual feedback on the phone's screen during recording. It also suggests that children age 6 may be capable of playing the role of "adult" in such communication systems, and that such systems may be adapted for peer-based communication for elementary aged children. Our future research will address these possibilities.

Remarks

Play with Elmo is based on several assumptions and design guidelines: (1) Young kids need real-time social interaction in order to engage, so we pretend everything is "live." (2) Grown-ups may not know how to be silly and engage children, so prompting by a trusted children's character can help. (3) Grown-ups want feedback from the children to know their messages are appreciated. (4) Young children don't understand software "modes" so we can't ask them to do grown-up things like "reply" to a message. Their responses to a message should instead be captured at the moment they happen.

While *Play with Elmo* was clearly responded to as a toy and plaything, children's approach to *Play with Elmo* was more akin to watching television than to classic play with toys. While the videos were short, their 10-20 second length may have come across to the children as being more like short-form narrative than like the interactive photo game that children found in the Orange Toaster. The initial feedback children received from this toy was the song and pop-up after they pressed the toy down, with the video playback following this dramatic episode. While we hoped the video watching would be accompanied by performative play, this did not happen in the preschool environment nearly as much as in did in earlier studies in a home environment. This was likely due to the lack of visual feedback. With the Orange Toaster children were visually rewarded (with self portraits) for their performances, whereas in Play with Elmo, they were not. A better design might display the child's performances live on screen, helping children to understand that they are part of the performance. Further investigations will help us to understand how to best scaffold children's involvement and play in order to maximize the engagement of all of the parties involved in asynchronous family communication.

DISCUSSION

Our three experiments each explore a unique possibility for asynchronous messaging for very young children. *Orange Toaster* illustrates a compelling toy mechanic for children to generate self portraits; *Family Toast* illustrates a way for children to choose and navigate among a large set of family photos; *Play With Elmo* illustrates how adults can be scaffolded to play with remote children in the "here and now" to create a sense of connection across space and time (Table 1). While these three projects do not converge on a single ideal solution *per-se*, they do lead to a number of general findings and guidelines that may be followed in future work on this topic. We return to three key learnings:

- children's UI's need to be playful and immediate to fully engage children
- designs with a specific temporal context may confuse young children. If possible, it is preferable to simulate the "here and now" feel of real-time interaction.
- adults' UI's must be content-rich and provide emotionally meaningful feedback to motivate adults' use.

Design Guidelines

Based on these experiments, we draw design guidelines for asynchronous UI models to connect children and adults.

For Children's devices

- Tangible UI's are more accessible to very young children than purely graphical ones.
- Classic Toy designs bootstrap tangible designs to improve child engagement and can inform UI affordances.
- Classic game and toy play patterns can inform UI and content designs and flow
- Very young children will experience play "here and now" and designs should leverage this.
- Feedback should be multi-modal and immediate.
- Children will likely not understand remote communication functions. These may easily (and profitably) be hidden from them.
- For privacy reasons, recording should be made obvious to adults and control given to them over recorded content.

For Adults

- While children do not understand the capacity for communication, adults do, and privacy concerns are central. Recording should be made obvious to adults and control given to them over recorded content.
- UI's for adults should leverage skills and knowledge adults already have. GUI's are likely more accessible to adults and can be leveraged.
- Adults may be scaffolded to "play" with children in ways that are appropriate for the child's age, and in the "here and now" using various forms of content.

Lastly, we propose that *systems need to provide bidirectional communication and feedback* to be considered a complete asynchronous communication system. While our designs do not all meet these criteria, they begin to illustrate how such complete systems may be created by future researchers and designers.

FUTURE WORK

Three directions demand future research. First, we believe the community can build on these early results to create full-featured and functional asynchronous communication systems for adults and very young children. We intend to pursue this goal and hope others will join us in the endeavor. Second, these systems need to be more fully evaluated in-situ, over long durations. The results reported here focus largely on UI designs for children, with early explorations for adult users; more complete analyses of family use as a whole would contribute greatly to this line of research. Finally, we feel the child development community may contribute meaningfully to inform content and UI design for very young children. Child development experts have begun to explore how very young children may perceive and make sense of the kinds of content created on such systems. However, more research is required in order to evaluate how asynchronous messaging systems may influence children's development and learning. For example, we assume asynchronous messaging systems are best used by children with co-present caregivers, to help explain content to children. Such questions should be explored further.

CONCLUSION

We have presented three unique systems for very young children to engage in asynchronous communication with loved ones who are far away. This goal confronts the

	Adult Co Sour
Orange Toaster	–
Family Toast	Photo adul
Play with Elmo	Vide recorde adults, Elmo, webs

Table 1. Compr

challenge that very young children experience the world largely in the "here and now," and asynchronous messaging is, by definition, neither *here* nor *now*.

Our designs focus on a toy-like system called "Toaster" which is a Jack-In-The-Box style toy with associated smartphone for multimedia and communications functions. Our three experiments each illustrate opportunities for future research, by showing that it is possible for (1) young children to engage in creating personalized content, (2) young children to browse and enjoy libraries of content created by remote family members, and (3) adults to engage in age-appropriate play with young children through scaffolding by a trusted children's character. This work argues for hiding communication features from young children, and creating asymmetric UI's that are uniquely designed to take advantage of the skills and knowledge of the young and old.

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