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ABSTRACT

Hello Barbie, CogniToys Dino, and Amazon Echo are part of a new wave of connected toys and gadgets for the home that listen. Unlike the smartphone, these devices are always on, blending into the background until needed. We conducted interviews with parent-child pairs in which they interacted with Hello Barbie and CogniToys Dino, shedding light on children's expectations of the toys' "intelligence" and parents' privacy concerns and expectations for parental controls. We find that children were often unaware that others might be able to hear what was said to the toy, and that some parents draw connections between the toys and similar tools not intended as toys (e.g., Siri, Alexa) with which their children already interact. Our findings illuminate people's mental models and experiences with these emerging technologies and will help inform the future designs of interactive, connected toys and gadgets. We conclude with recommendations for designers and policy makers.

ACM Classification Keywords

H.1.2 User/Machine Systems: Human factors; J.7 Computers in Other Systems: Consumer products; K.4.1 Public Policy Issues: Privacy

Author Keywords

Connected toys; Children; Parents; Privacy

INTRODUCTION

Connected toys are becoming more and more commonplace. From TROBO—a stuffed robot with a storytime app—to My Friend Cayla, Hello Barbie, and CogniToys Dino, there are a

Figure 1. Example connected toys: (a) CogniToys Dino, (b) Hello Barbie, (c) SmartToy Monkey, (d) My friend Cayla, (e) TROBO the Storytelling Robot, (f) Jibo. Our study involved (a) and (b).

wide variety of Internet-connected toys available today (see Figure 1). Marketing campaigns for these toys emphasize their potential educational and developmental benefits, as well as their interactivity and open-ended, dynamic content to attract both parents' and children's attention. These functions are enabled by having the toys always on and always connected to the Internet.

This constant connection poses privacy threats and new vulnerabilities not previously experienced in the realm of toys. While they are similar in nature to Internet-connected devices such as Amazon's Echo, toys are particularly problematic because the user is typically a child. It is recognized that children are uniquely vulnerable online; for example, in the United States there are specialized laws created to protect children online (e.g., the Children's Online Privacy Protection Act, or COPPA). Besides concerns about companies collecting data, these toys also raise potential ethical concerns such as parents spying on their children.

The privacy concerns surrounding children's data are not theoretical. VTech, a company that produces tablets for children, was found to have been storing the personal data of 5 million parents and over 200,000 children (including pictures and chat logs) when it was hacked, making it possible to fully identify and locate the children [14]. ToyTalk and Mattel's Hello Bar-

bie was quickly met with controversy upon its release, with Twitter hashtags such as `#HellNoBarbie` and an outline of the downsides to a connected toy, identifying issues with privacy, by the Campaign for A Commercial Free Childhood [13]. ToyTalk drew additional attention for a privacy policy that appeared to allow the company wide latitude with the use of children's recordings [32].

Researchers have begun studying these toys from a technical security and privacy perspective and have raised theoretical concerns about parent attitudes and child privacy [10, 25]. Our goal in this work is to investigate the human side of the equation: to ground this conversation in an empirical investigation of parents' and children's interactions with, attitudes about, and mental models of connected toys. Before we can design better toys, we must understand the privacy and interaction expectations of parents and children.

To that end, we conducted semi-structured interviews with nine parent-child pairs, with two representative connected toys: Hello Barbie and CogniToys Dino. We examined the following research questions:

- *General interaction:* How do parents and children interact with Internet-connected toys? What are their expectations and mental models for these interactions?
- *Privacy:* What are the privacy expectations and concerns of parents for connected toys? What are children's mental models of their privacy when interacting with the toy?
- *Parental controls:* What parental controls do parents wish to exercise?

We find, for example, that children are often unaware that the toys record what is said to them; meanwhile, most parents have privacy concerns about the toys while some appreciate the opportunity for monitoring their children. We also find that children quickly learn the repetitive loops of the toys and desire richer, more flexible interactions—interactions that many may already be exposed to through interactions with platforms like Siri and Google Now, suggesting that these platforms require similar scrutiny with respect to their use by child users.

Taken together, our findings begin to outline parent and child mental models and experiences with these emerging technologies and will help inform the future designs of interactive, connected toys. We conclude with recommendations for toy designers and policy makers.

RELATED WORK

There have been studies of these toys from a security and privacy perspective. ToyTalk has even developed a bug bounty program to find security flaws [16]. Others have raised theoretical concerns about parent and child interaction with these toys and the privacy implications [32, 13]. Here we review related work on children and technology, Internet-connected toys, and since robots have been extensively studied for these same issues we include a review of relevant robotics research.

Children and Technology

Research on children's interactions with technology occurs across disciplines and research involving children in the de-

sign of new technology is a growing field [36]. Exploring parent and child reactions through studies where they are interviewed in pairs is common [18, 35, 8]. Studies have explored how young children perceive their computer use [24], involving children in content control [18], and reactions to health monitoring technology [33].

While children typically do not have a role in the design of new technologies, their position as a growing consumer group makes their input increasingly important to the development of technologies they find useful and meaningful. Children can be a part of the design process at each stage of development. Roles such as the user, the tester, the informant, and the design partner offer different ways to engage children and iterate based on their feedback [11]. Research has also been done to understand how parent-child relationships in families shape co-design processes and how they are reshaped through co-design [36]. Value-sensitive design, a design approach that accounts for the human values of direct and indirect stakeholders, has been used to explore parent and teen perspectives on technologies that allow parents to monitor their children [8].

Technology-based toys are increasingly popular with children [6]. In previous work on smart toys, authors identified some of the unique features that connect with different developmental stages. Prior work exploring what children would like in a robot has shown children's desire to have interactive toys [4]. Children have also been found to prefer playing with a robot to playing alone [28]. The same study found that children prefer playing with friends as compared to playing with a robot.

Our work continues the theme of exploring parent and child reactions to technology, examining mental models of Internet-connected toys held by parents and children.

Internet-Connected Toys

Parents are increasingly concerned about online privacy for their children [19, 23]. They are also concerned about the amount of screen time their child experiences [34]. Internet-connected toys like Cognitoys Dino may provide the interaction some parents would like without an increase in screen time.

The challenges of developing a toy that addresses parents' concerns are not insignificant. Shortly after the release of Hello Barbie and with Cognitoys Dino in development, an editorial labeled smart toys "the stuff of nightmares" [32]. The authors identified issues with Hello Barbie prompting children for personal information, faulted the privacy policy, and expressed concerns for the toy's invasion of play. Identifying that children need private spaces to engage in play without adults interfering, the authors worried that the recordings made available to parents would invade the child's privacy.

In early work on the privacy and security of Internet-connected toys privacy and security issues were found in many connected toys [10, 25]. Hello Barbie has been complimented for its strong encryption practices, though its websites were sometimes found vulnerable [27]. Both Cognitoys Dino and Hello Barbie have been cited as leaders of security practices for connected toys [10, 30].

Research on whether Hello Barbie could keep a secret examined the toy's ability to respect privacy. Comparing Hello Barbie to Furbie and other advanced toys from the previous twenty years, the researchers noted that the ability to record and share a user's conversations distinguished the Hello Barbie in a negative fashion. They concluded that the implications of extensively sharing data could negatively affect children's ability to trust and undermine parental authority in managing their child's data [20]. Similarly, a recent complaint [7] filed with the Federal Trade Commission regarding My Friend Cayla (a toy similar to those we studied) highlighted several security challenges with this toy.

Finally, a recent whitepaper from the Future of Privacy Forum and Family Online Safety Institute [1] explores the potential impact of connected toys and connected homes on the privacy of children, including the role of the Children's Online Privacy Protection Act (COPPA).

Household Robots

With the relatively recent appearance of connected toys, relevant research on listening devices in the home can be found in studies of household robots, which may share interaction and privacy characteristics with toys. For example, one study of security and privacy of household robots found that robots present different risks than traditional computing devices, as they potentially allow third parties to have eyes, ears, and hands inside the home [9]. The authors recommended that developers treat private data that could be collected about a person as confidential. Others have asked individuals to describe their ideal household robots to guide design efforts to better reflect user needs [31]. Indeed, researchers found that safety and the secure storage of sensitive information were main concerns for users of domestic robots. At the same time, participants were happy to have a robot store information where it was essential to improve the robot's functionality [22]. A related study on the balance between the efficacy of remotely-operated household robots and user privacy found that users would like to control access to information in the home, and that it may be possible to filter video feeds in a way that balances privacy with efficacy [5].

From a policy perspective, researchers have asserted the use of household robots will require a new examination of the expectations of privacy in the home [21]. Consumer robots will also raise new consumer protection issues, e.g., for the Federal Trade Commission, which is often sensitive to the risks of manipulation of vulnerable populations, such as children and the elderly [17]. Additionally, research discusses how the Fair Information Practice Principles may affect the emergence of cloud-enabled domestic robots [26]. Other work identifies the regulatory gaps affecting homecare robots, recommending a premarket review of robot safety to look more broadly at the potential harms, such as security and privacy [29].

METHODS

In this work we seek to better understand parent's and children's mental models of Internet-connected toys and their perception of privacy implications, in order to provide designers and policy makers with relevant recommendations. To that
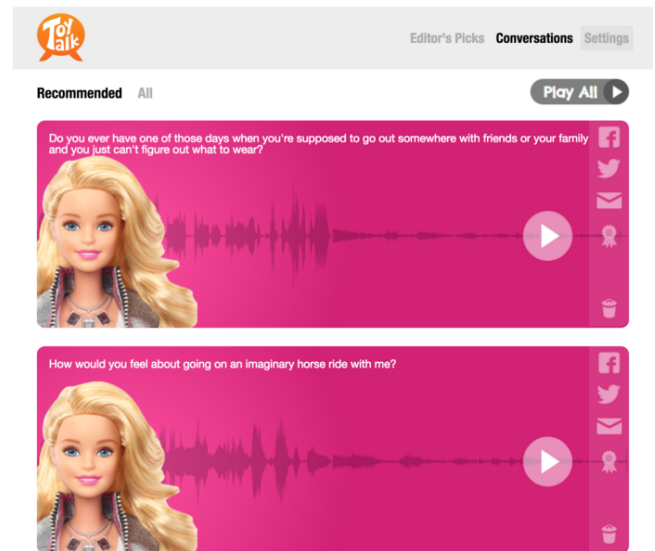

Figure 2. Screenshot of the Toytalk Hello Barbie parent panel that allows listening to the child's responses to various questions that Barbie asks, as well as sharing them on social networks.

end we conducted semi-structured interviews with parent-child pairs, following a demonstration and an interaction session with two different toys and their associated apps.

Toys

We selected two current toys for our study: Hello Barbie and CogniToys Dino. We chose Hello Barbie because it has received significant recent attention, and we chose Dino because it presents less of a gender-association than Barbie. We used two different toys because we expected to have male and female participants and thought boys might be reluctant to play with Hello Barbie or girls with Dino. Additionally, using both toys allowed us to observe interactions with both Barbie's predetermined answers and Dino's more open-ended model.

While Hello Barbie has received significantly more public attention, Dino currently has significantly more positive reviews, 59% five star reviews (of 73) on Amazon compared to 20% (of 101) for Hello Barbie [3, 2]. Barbie also has 57% one star reviews, many due to technical issues around set-up and charging. Dino is advertised as an educational toy that can learn from its user and won the 2014 mobile developer IBM Watson award [12].

Both toys connect to the Internet via wifi. Barbie can respond only with pre-determined responses, while Dino uses IBM Watson to attempt to respond to arbitrary questions. Both toys have an associated smartphone app for parents that includes parental control settings (in Dino's case, this only includes a bedtime). Parents can use the associated Barbie website to listen to and share recordings of their child's conversations with the toy (Figure 2); Dino has promised a Parent Panel dashboard, but it does not yet exist.

Recruitment

We recruited participants by sharing an announcement with local parent groups, emailing listservs, and posting on Facebook. The recruitment message requested participants who

Identifiers	Child Gender	Child Age	Parent Gender
P1, C1	F	6	F
P2, C2	M	10	F
P3, C3	M	6	M
P4, C4	M	8	F
P5, C5	M	6	F
P6, C6	M	7	F
P7, C7	F	9	F
P8, C8	F	7	F
P9, C9	M	6	F

Table 1. Overview of Study Participants.

had children between the ages of six and ten. The request for participants did not require individuals to have experienced or own any of the toys. Through online recruitment and word-of-mouth we were able to recruit over thirty people to fill out an eligibility survey. We asked questions about experience with the selected toys and parent's use of social media for baseline purposes but these answers did not affect eligibility. From the survey respondents, we were able to schedule interviews with nine pairs of participants.

Participants' gender and children's ages are detailed in Table 1. Only one of the participants had previously used any of the toys. All participants were from the Seattle metro area. Participants came from high and low socioeconomic classes, including three from single income families. In our study, we did not observe significant differences between participants of different demographics, though such differences may exist in practice.

Interviews

Interviews were conducted in August 2016. The shortest interview was 40 minutes and the longest was 70 minutes. All interviews were conducted in person with two researchers present. One researcher worked with the child, while the second researcher interviewed the parent. The study started with both the parent and the child in the same room. The study protocol proceeded as follows.

Each toy was demonstrated to the child while the parent observed. Researchers demonstrated Dino explicitly, while Hello Barbie was demonstrated through the setup of the app with the parent. Once set up, Barbie provides some guidance for the child through her first few statements, and researchers provided additional guidance if needed.

Children were first asked to play with the toy while the parent observed, and were then moved to a different space with the toy and one of the researchers. We separated children and parents for a portion of the interview because children may experience the toy differently without their parent present. As the child played, a researcher asked them questions about how the toy works and, if needed, prompted the child to ask the toy questions and to play games with the toy.

Parents were not explicitly asked to interact with the toys, but were present for both initial demos and playtime and many participated with their child in asking the toys questions.

All children first played with Dino and then with Barbie. We used the time while the child played with Dino to guide the parent through the setup process of the Hello Barbie app.

After the child left to play with the first toy (Dino), the parent was interviewed with a first set of questions:

- Have you heard of the toys or seen ads?
- What kinds of things would your child ask such a toy?
- Does your child talk to other devices that are not explicitly toys?
- Would you consider having such a toy in your home?

After all questions above and any follow up questions were answered, the parent was asked to set up the application associated with the Hello Barbie. Then the child was brought back into the same space as the parent and the parent observed the child play with Hello Barbie, before the child was again brought to another space to play with Hello Barbie without the parent present.

While the parent and child were separated, we conducted the second part of the interview. The parent interview focused on the parent's mental model of the toy, with questions regarding parental controls, privacy, and monitoring what the child says to the toy. We asked:

- What parental controls would you expect the toy to include?
- What do you expect to be in the toy's manual and privacy policy?
- How did you feel about the ability to monitor what your child says to the toy?
- Would you share what your child said to the toy on social media?
- Would you consider purchasing the toy?

In the second part of the child interview, after they had an opportunity to play with both toys, we asked them questions to elicit their mental model of each toy and privacy perceptions. This interview phase occurred only once, after the child had played with both toys. We asked:

- What did you like about the toy?
- What would you talk about with the toy?
- Do you think the toy can remember what you say to it?
- Would you tell the toy a secret?
- Do you think your parent could hear what you said to the toy?

IRB and Ethics

This study was approved by our institution's human subjects review board. We did not seek to elicit private information from the child, asking questions about their perceptions rather than asking them to tell the toy a secret.

Data Analysis

To analyze the interviews, we used a grounded theory [15] approach in which we developed a set of themes, via an iterative process. We first transcribed the interviews and analyzed the participants answers to our structured questions. Two researchers then independently coded each interview, while

Identifiers	Toy remembers?	Tell a secret?	Parent can hear?
C1	Yes	No	Depends
C2	No	Maybe	Maybe
C3	No	No	No
C4	N/A	No	No
C5	Some	Maybe	Probably
C6	Yes, but deletes it	No	No
C7	Maybe	Maybe	Probably not
C8	Yes	Yes	Maybe
C9	Yes	Yes	No

Table 2. Summary of children's answers to the three closed-form interview questions.

iteratively developing a codebook through discussions with the rest of the research team. We conducted multiple passes, iterating until we began to see broader themes in participants answers. Conflicts between coders were resolved through discussion to arrive at full consensus.

RESULTS

We report on the results of our study, organized around four high-level themes: child-toy interaction, privacy, parental controls, and toys compared to other connected devices. We step back and synthesize these findings into recommendations in the Discussion.

Child-Toy Interaction

We begin by highlighting several aspects of children's interactions with the toys that we observed, which help set the context in which we observed privacy-related concerns or expectations. While not the central contribution of this work, we noted aspects of the toys predictability of responses and pre-programmed activities that may impact children's perception of the toys. We encourage future researchers to further study broader questions around children's interactions with connected toys.

Activities

Children asked and responded to a variety of questions with the toys. Both toys have preset games the user can participate in. Hello Barbie begins user interaction with a preset list of questions while Dino typically begins by asking what the user would like to do either play a game, create a story, or ask a question.

One popular activity was to ask Dino to tell jokes. However, some parents had concerns about the age appropriate nature of the jokes.

> I think also, as you could tell today, we thought those jokes were funny. I am 100 percent sure he did not understand. When it was like, beat up the turkey? Knock the stuffing out. Stuffing. 90 percent of the jokes, other than the knock-knock jokes, were above his head. He'll laugh at them because he knows it's right to laugh at them, and we were laughing at them, so he was laughing. The one thing I will say, the jokes at least weren't routine. They were new and creative. They were sometimes almost verging on inappropriate. For example, knock out the stuffing? There are some parents who would be more concerned with the violent nature of that joke. Especially

giving this to a younger kid. Even though the database of jokes was good, it's difficult when they're making this toy for a wide age-range that a two-year-old would have no idea any of these jokes. (P6)

Some children asked about the toys ability to move. C3 asked "Can you fly?" and Dino responded: "Only if you throw me."

Predictability

All of the child participants recognized when the toy went into a loop. Many became frustrated with Hello Barbie would not change subjects or respond to the child's question. While a loop was particularly evident with Hello Barbie, they also recognized Dino had a set of responses for when he did not know the answer or could not answer the question. One parent noted:

> [The toy says] "I'll look that up later," or whatever it says, and he's old enough to realize that it's being repetitive. (P6)

One parent (P7) followed up with us after the study session to say that her child began using Dino's repetitive phrases towards her father when she did not want to do what she was asked to do.

In comparison with Siri and other connected devices with which parents and children had prior experiences, the toys seemed limited and boring:

> My basic problems with this toy first is, he's seven-and-a-half. He has fairly free access to Siri and Alexa, so he, multiple times a day, will go up to his parental-controlled iPad and say, "What's the Mariner's score?" He is so accustomed to that now. When this thing didn't know things, it was incredibly frustrating to him, because this ... He loves sports. He would say, "How many times have the Mariners won the World Series?" Or he'd have some kind of question like that, and this wouldn't know it. Yet he can walk over to Siri and Siri's voice recognition is even better than this. (P6)

We return to a comparison of connected toys to agents like Siri below.

Privacy

Parents and children expressed opinions about monitoring, social media, and what parents might find out about their child's interaction.

Parents on Recording

Parents were sensitive to the issues surrounding monitoring what their child does with the toy as well as what data would be retained by the company.

Some parents expressed concern over the toys' ability to record and what the company would do with that data:

> I see something like this and I'm immediately like what is the purpose of recording, parents don't really need the recording, but are they gathering that data? Like is that what they need — googling it and getting a ton of data on kids and their interactions and then they can analyze all

Identifiers	P1	P2	P3	P4	P5	P6	P7	P8	P9
Would you share recordings on social media?	No	No	No	No	No	No	No	No	No
Should the toy have parental controls?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Toys seen as similar to Siri/Cortana/Alexa	No	No	No	Yes	N/A	Yes	Yes	Yes	Yes

Table 3. Summary of parents' answers to the three closed-form interview questions.

that data so I'm like, no if I could eliminate the recording I would definitely do it. (P8)

I would want to be present when they used it. I don't think it's something I would let my child use with somebody else unless I knew a lot more about it because it seems like it's a little interactive, and I don't know where this recording stuff is going. It feels permanent when you're speaking into her, like is she recording me and who can see or get this information? (P2)

I don't want kids listening to what my kid said to a doll without my supervision. (P7)

Two parents (P3, P5) directly stated that they would tell their child that the toy could record.

Another concern noted was the sheer number of recordings. One participant said:

My initial response is I don't have time to go through all these. Like I'm not going to click and listen. I have to be sorting through all the photos she took of herself on my phone because my phone is always full. This is just one more pile of media I would have to determine what's useful, should I save it, should I get rid of it, where should I put it? I think my initial inkling is don't even look at it so you don't have to make any decisions about what to do with it. (P8)

While their concern was the amount of time required to review the large number of recordings, it also raises the issue of the ability of parents to keep track of what data the company has on their child.

Some parents were skeptical but not overly concerned:

Initially this strikes me as creepy, and I'm not sure why. But, I guess the idea that she's over there just talking and having fun, and then I'm somewhere else logging in listening, like if I'm in another room or something, it just seems — and I don't really get the necessity of it, like why would I care? Why would I want to record this? And then I immediately think about how my son would use this tool to catch me saying something. (P8)

Similarly, the limited function of Hello Barbie led one parent to indicate it was unlikely that the recordings would be worth listening to:

Nice that you can see what they're answering, but the questions that she asks doesn't seem like anything that I'd be interested in knowing my kids responses. (P5)

On the other hand, some parents saw positives in the potential to use recording to monitor their children:

I like that ... if I felt like something was inappropriate, I can have a conversation with my kids about what they were saying, but I'd rather be proactive about it and get a notification or something instead of having to go on there and monitor myself. (P2)

I think it could be useful if I was concerned about something that she was going through and I felt that in the event that this was an ally for her it would be a chance for me to know what was going on, but I also think that in the best of worlds she would be able to be saying those things to me directly. I suppose that some parents might use it as a touchstone to find out what's going on in their kid's head. (P1)

Parents on Sharing
All parents would *not* share recordings from the toys on social media (see Table 3). Several said they would not share in order to respect their child's privacy:

I think past a certain age you need to respect your child's privacy and idea that they might not want what they say to be shared amongst your gaggle of friends. I think for some people it works, for me personally it's not something that I would use. (P4)

The child is not consenting to the questions they ask Barbie to be shared on Facebook. (P6)

Others thought the toy was unlikely to illicit any interesting response worth sharing on social media.

Children's Privacy Expectations
Table 2 summarizes children's answers to three of the questions in the interview. We saw that some of the child participants did not recognize that the device might be recording. Six children did not think their parents would be able to hear what they said to the toy unless the parent was nearby. Two indicated that their parents may be able to hear what they said. Only one participant explicitly said their parent would be able to hear if the device was recording (C1).

When asked if they would tell the toy a secret, four children said no, two said yes, and one did not answer the question. These responses sometimes suggested inconsistency in the child's mental model. For example, one child who understood that the toy remembers things, still expressed that he would be willing to tell it a secret.

One parent explained that the toy could record and the child had a negative reaction.

Parent: Hey, did you know that Barbie doll, when you're all done, everything that you share with her would end up on the computer so we could talk about it? Would that make it fun for you? (P9)

Figure 3.   The ToyTalk Hello Barbie set-up email, with the distinct "I Give Permission" button.

Child: That's pretty scary. (C9)

Parental Controls

All parents expressed that the toys should have parental controls (see Table 3). In this context parental controls include what questions the toys will answer and when the toys work—e.g., the ability to set bedtime on Dino and disconnect Barbie from the Internet. In contrast, no parent commented on the email they received during the Hello Barbie setup process, which asked them to agree to allow their child to play with the toy. Most parents quickly clicked through screens requesting their assent, without comment.

Parental Permissions

Rather than a typical terms of service with an "I accept" button, ToyTalk sends parents a set-up email that includes a large orange button with the text "I give permission" (Figure 3). This entails permission for the child to play with the toy as well as permission for Toytalk to audio record the child's interaction with the toy. No participant noted the affect of the text used to grant permission. All clicked to allow their child to play with the toy.

The company also provides a related parental control. Within the settings tab of a parent's account, in addition to a "Delete My Account" there is an option to "Revoke Permission." One participant (P8) chose to click this button, and within a minute the Hello Barbie that their child was playing with no longer worked.

Another noted control was the ability to set a bedtime for Dino after which the child would no longer be able to play with Dino.

Well, and I will say I'm in an era now where I would love any kind of I pull out my phone and I can stop any device that anybody has at any time, and I can just be like we talked about this half an hour ago, you were supposed to be done. (P8)

Content Controls

While Barbie has canned responses, Dino uses IBM Watson to respond to arbitrary questions from children. Many parents expected that there would be language filters or controls. When asked what controls the device should have, some suggested an alert based on language used.

Some sort of language settings or content settings. Some sort of alert, maybe? A way to alert parents if questions that are ... if there are questions that are raising filters or warnings and alert the parents, so a more active monitor rather than the parents having to go check. (P5)

Something where I could control the language, like what words they could or couldn't say, the toy. Maybe red flags. If my child said a specific word that it would automatically turn off or give some kind of notification or something like that. (P2)

One parent noted that while she assumed the toy would filter content, the toys' capabilities were so limited she was not concerned:

I would assume that it would filter for content deeply. But then, I soon realized, when it wasn't capable of answering so many of his questions, I was like, "I'm not that worried about it." (P6)

Several said that they are careful with parent settings on other devices:

There's an app that you set it up with the first time. I didn't do anything. I assumed, because it was designed for children, that it would have built-in ... It's not like you get an iPhone and you're like, "I'd better lock this down." I just made the assumption that it was. (P6)

Participants also commented on the ease of set-up for parental controls.

I assume now, when something is like this, it will just walk you through the basic settings that you need to know. I do become quickly frustrated when something isn't clear, or I'm like how do I do that. I like things to be convenient and easy, and once it gets complicated, I really am ready to bail on any kind of tech. Especially where this one is for entertainment and not learning. Then I have a low tolerance for how much I'm willing to do to set it up and make it work right. (P8)

One parent reflected on the futility of implementing parental controls:

I mean if it walks you through parental controls, again, we just purchased a little while ago that Disney circle app that controls online access and kind of walks you through how to set up different devices, and then it was horribly

disappointing when both my kids figured out ways to do things offline on their devices, and I was like oh wait I can't control any of that, this isn't going to work. (P8)

Toys vs. Other Connected Devices
We asked parents whether their child had interactions with other responsive systems such as Siri, Cortana, OK Google, and Alexa. Five parents (see Table 3) explicitly observed that Dino was similar to Siri and other artificial intelligence voice recognition systems.

I think the chief difference is just that I ultimately have ownership of Cortana and would let her use it in a very limited basis with my supervision, and this is something that she might use on her own. I would just need to build in that accountability piece where I'm monitoring the usage. (P1)

Yeah, so maybe I could see the Dino thing more being like a learning toy that can tell jokes and things, but you could go to it to gather information, kind of like Siri for kids. (P8)

That is, many children may already interact with Internet-connected devices and services that share properties with connected toys.

DISCUSSION
Based on our findings in the previous section, we now step back and reflect on recommendations for toy designers and policy makers.

Recommendations for Toy Designers

Security and Privacy
We make several recommendations for toy designers related to security and privacy of the toys.

First, we suggest that toys better communicate with parents and children that the toy is recording, through the use of visual or other *recording indicators*. Several parents indicated they would inform their child the toy was recording; the toy itself could be designed to help build the correct mental model. In addition to passive indicators, a feature that allows children to control and listen to their own recordings would make recording an opt-in feature and provide greater awareness for children of the toy's capabilities.

More fundamentally, we suggest that toy designers reevaluate the need to record and store children's conversation with the toys. While we recognize some data transmission is necessary to complete and improve voice recognition, there are options for improved data practices. Possible practices that would reduce the risk of accidental data exposure or sharing, and may alleviate parents' and others' privacy concerns, include deleting recordings both from the app and from the server after a fixed time (e.g., 7 days) and local processing that reduces the need to send recordings to the cloud.

Communicating with parents about the privacy and security properties of these toys may also increase their willingness to allow their children to play with them. For example, a

Hello!

Welcome to the ToyTalk community.

ToyTalk is a family entertainment company that creates conversational characters, and we believe that talking inspires creative minds.

We also believe transparency and trust go hand in hand and that parents should have direct control of their family's data and privacy.

As you start your ToyTalk experience, we'd love to know which character is your family's favorite. Please drop us a line on Twitter, Facebook, or Instagram, or just email us. We'd love to chat.

Thanks again for your time and happy playing.

Best,

Oren

Oren Jacob
CEO

imagination + conversation

Contact | Terms | Privacy

Figure 4. ToyTalk follow-up email

follow-up email like that in Figure 4 provides parents with an additional opportunity to engage in privacy decisions. Of course, such assurances should also be paired with *strong technical security and privacy best practices*.

Finally, providing the ability for parents to *monitor their children* raises potential ethical and trust issues (e.g., [8, 20]) that toy designers must consider. Parents may also not realize that for the toys to support technically sophisticated monitoring features (e.g., alerting parents via email or an app when specific topics are discussed) requires children's interactions with the toy to be recorded and processed. Thus, the desire to monitor children as a parent while preserving privacy from third parties may be at odds.

Child-Toy Interaction
In terms of child-toy interaction, *flexible interaction* seems important. Our child participants were most engaged when asking questions of their own choosing. For that use, Cognitoys Dino worked very well. The toy was also much less likely to be caught in a game or story loop, allowing the children to ask questions whenever they liked. However, to support such flexible interactions and responses to non-pre-determined questions, the toy requires Internet connectivity, raising potential concerns about privacy and the appropriateness of responses that are returned.

Another aspect of toy-child interaction that we observed was the importance of *integrated instructions*. One of the features our participants found most helpful was Hello Barbie's instruction reminder. When Barbie does not understand, she re-explains to the user to push and hold the recording button. By contrast, children needed more demonstration from researchers in getting started with Dino.

Non-Toys with Child Users

Our study highlights that platforms like Siri, Cortana, Google Now, and Alexa are already used by children, and that children may interact with them in similar ways as they interact with connected toys. These non-toy platforms may help shape children's mental models of toys, and may raise similar issues around privacy and content. The designers of these platforms should thus consider children as potential (co-)users in their designs.

Recommendations for Policy Makers

Investigate and Communicate Privacy Issues

As Internet-connected toys become more common, it will be more important for consumers and parents in particular to understand how they work (e.g., are recordings stored? can recordings be shared?) and the implications for children. As one strategy, more could be done to educate consumers about the existing seals on toys that indicate the toy is certified to comply with laws designed to protect children's privacy (i.e., data collection and storage processes have been audited). Figure 5 shows an example of the seal for KidSAFE, which has certified Hello Barbie.

Several parents indicated they would tell their child in an age appropriate way when a toy has the ability to record. We recommend policy makers work with consumer protection enforcers and nonprofits to help parents realize that their children's mental models about the toy's capabilities may be mistaken, and to help guide toy designs to elicit more accurate mental models (e.g., through recording indicators).

Enforce Existing Child Privacy Protections

In light of preferences parents expressed in this study regarding data collection and privacy, policy makers would be well-placed to encourage ongoing enforcement of existing privacy protections for children's data such as the Children's Online Privacy Protection Act (COPPA) in the United States. Regulatory safe harbors that encourage creation of programs where toy designers can be audited for their practices around children's data and certified compliant, provide parents and toy designers guidance towards successful outcomes.

Toys are Not Unique

Parents reported that their children regularly interact with systems like Siri and Cortana. While toys receive much scrutiny for the evident child involvement, non-toy devices should be similarly examined for regulatory compliance. Policy makers should be aware that all of these connected devices may share similar issues when children interact with them, including privacy concerns and the appropriateness of content. For instance, while Dino was designed to have child-safe answers, not all toys or devices may be designed to take the same precautions.

Limitations

Finally, we reflect on the limitations of this study. Our study was conducted with a relatively small sample size, with limited demographic diversity. Because the interviews were conducted in person, our demographic sample was limited to the Seattle metro area. The fact that we did not randomize the order in

Figure 5. KidSafe certification seal.

which children played with the toys may have affected their impressions and interactions. There may also have existed potential priming effects in the initial questions that could have led participants to discuss privacy concerns. We also recognize that privacy decisions in a lab setting may be different than those made at home.

Despite these limitations, we believe that this work represents an important first look at parent and child interactions and attitudes with these connected toys, particularly from a privacy perspective, and we hope that it will inspire future and ongoing work in this space.

CONCLUSION

In this paper we presented the results of a user study with nine parent-child pairs. We observed as children and parents interacted with two Internet-connected toys, Hello Barbie and CogniToys Dino, and interviewed participants to elicit their privacy expectations and mental models about interactions with these toys. We found that many parents have mixed attitudes about the recording capabilities of these toys, but typically voiced privacy concerns; that children often did not realize the toys were recording or that the recordings were accessible to their parents; that the toys' interactions models are not yet sufficiently sophisticated and flexible for children's expectations; and that children are already frequently exposed to devices that listen and interact but are not designed as toys (e.g., Siri, Alexa). This work lays a foundation for understanding parents' and children's mental models and expectations for these toys and suggests directions for toy designers and policy makers.

REFERENCES

1. C. Alonso, S. Gray, E. Morris, J. Hanley, S. Anderson, H. Jiang, and E. Tabatabai. 2016. Kids & the Connected Home: Privacy in the Age of Connected Dolls, Talking Dinosaurs, and Battling Robots. Future of Privacy Forum and Family Online Safety Institute. (2016). https://fpf.org/wp-content/uploads/2016/11/Kids-The-Connected-Home-Privacy-in-the-Age-of-Connected-Dolls-Talking-Dinosaurs-and-Battling-Robots.pdf.

2. Amazon. 2016a. Barbie - Hello Barbie Doll. (2016). https://www.amazon.com/Barbie-DKF74-Hello-Doll/dp/B012BIBAA2.

3. Amazon. 2016b. Cognitoy Dino, Powered by IBM Watson. (2016). https://www.amazon.com/CogniToys-Powered-Cognitive-Electronic-Learning/dp/B014IO4HYS.

4. Lindsey Arnold, Kung Jin Lee, and Jason C. Yip. 2016. Co-designing with children: An approach to social robot design. In *ACM Human-Robot Interaction (HRI)*.

5. Daniel J. Butler, Justin Huang, Franziska Roesner, and Maya Cakmak. 2015. The Privacy-Utility Tradeoff for Remotely Teleoperated Robots. In *10th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*.

6. Kursat Cagiltay, Nuri Kara, and Cansu Cigdem Aydin. 2014. Smart Toy Based Learning. In *Handbook of Research on Educational Communications and Technology*, J. Michael Spector, M. David Merrill, Jan Elen, and M. J. Bishop (Eds.). Springer New York, New York, NY, 703–711.

7. Kate Cox. 2016. These Toys Don't Just Listen To Your Kid; They Send What They Hear To A Defense Contractor. The Consumerist. (Dec. 2016). https://consumerist.com/2016/12/06/these-toys-dont-just-listen-to-your-kid-they-send-what-they-hear-to-a-defense-contractor/.

8. Alexei Czeskis, Ivayla Dermendjieva, Hussein Yapit, Alan Borning, Batya Friedman, Brian Gill, and Tadayoshi Kohno. 2010. Parenting from the Pocket: Value Tensions and Technical Directions for Secure and Private Parent-Teen Mobile Safety. In *Symposium on Usable Privacy and Security (SOUPS)*.

9. Tamara Denning, Cynthia Matuszek, Karl Koscher, Joshua R. Smith, and Tadayoshi Kohno. 2009. A Spotlight on Security and Privacy Risks with Future Household Robots: Attacks and Lessons. In *Proceedings of the 11th International Conference on Ubiquitous Computing (UBICOMP)*.

10. Danielle L. Dobbins. 2015. *Analysis of Security Concerns and Privacy Risks of Children's Smart Toys*. Ph.D. Dissertation. Washington University St. Louis, St. Louis, MO, USA.

11. Allison Druin. 2002. The Role of Children in the Design of New Technology. *Behaviour & Information Technology* 21, 1 (2002), 1–25.

12. Elemental Path. 2014. Elemental Path. (2014). http://elementalpath.com/.

13. Campaign for a Commercial Free Childhood. 2015. Hell No Barbie: 8 reasons to leave Hello Barbie on the shelf. (2015). http://www.commercialfreechildhood.org/action/hell-no-barbie-8-reasons-leave-hello-barbie-shelf.

14. Lorenzo Franceschi-Bicchierai. 2015. One of the Largest Hacks Yet Exposes Data on Hundreds of Thousands of Kids. *Motherboard* (2015). http://motherboard.vice.com/read/one-of-the-largest-hacks-yet-exposes-data-on-hundreds-of-thousands-of-kids.

15. B.G. Glaser and A.L. Strauss. 1967. *The Discovery of Grounded Theory: Strategies for Qualitative Research*. Aldine Publishing Company, Chicago.

16. HackerOne. 2016. ToyTalk Bug Bounty Program. (2016). https://hackerone.com/toytalk/.

17. Woodrow Hartzog. 2015. Unfair and Deceptive Robots. In *Maryland Law Review (74)*.

18. Yasmeen Hashish, Andrea Bunt, and James E. Young. 2014. Involving Children in Content Control: A Collaborative and Education-Oriented Content Filtering Approach. In *Conference on Human Factors in Computing Systems 2014 (CHI)*.

19. Donell Holloway, Lelia Green, and Sonia Livingstone. 2013. Zero to Eight: Young Children and Their Internet Use. In *EU Kids Online*. LSE, London.

20. Meg Leta Jones and Kevin Meurer. 2016. Can (and Should) Hello Barbie Keep a Secret? *IEEE International Symposium on Ethics in Engineering, Science, and Technology* (2016).

21. Margot E. Kaminski. 2015. Robots in the Home: What Will We Have Agreed To?. In *Idaho Law Review (51)*. 661.

22. Kheng Lee Koay, Dag Sverre Syrdal, Michael L. Walters, and Kerstin Dautenhahn. 2009. Five Weeks in the Robot House - Exploratory Human-Robot Interaction Trials in a Domestic Setting. In *Proceedings of the Second International Conference on Advances in Computer-Human Interaction (ACHI)*.

23. May O. Lwin, Andrea JS Stanaland, and Anthony D. Miyazaki. 2008. Protecting Children's Privacy Online: How Parental Mediation Strategies Affect Website Safeguard Effectiveness. In *Journal of Retailing 84*. 205–217.

24. S. McKenney and J. Voogt. 2010. Technology and young children: How 4-7 year olds perceive their own use of computers. In *Computers in Human Behavior 26*. Elsevier, 656–664.

25. Ken Munro. 2015. Fight! Fight! Hello Barbie vs My Friend Cayla. Pen Test Partners. (18 February 2015). https://www.pentestpartners.com/blog/fight-fight-hello-barbie-vs-my-friend-cayla/.

26. Andrew A. Proia, Drew Simshaw, and Kris Hauser. 2015. Consumer Cloud Robotics and the Fair Information Practice Principles: Recognizing the Challenges and Opportunities Ahead. *Minnesota Journal of Law, Science and Technology* 14 (2015), 145.

27. Somerset Recon. 2016. Hello Barbie Security. (2016). http://www.somersetrecon.com/blog/2016/1/21/hello-barbie-security-part-2-analysis.

28. Suleman Shahid, Emiel Krahmer, and Marc Swerts. 2011. Child-robot Interaction: Playing Alone or Together?. In *CHI '11 Extended Abstracts on Human Factors in Computing Systems (CHI EA '11)*.

29. Drew Simshaw, Kris Hauser, N. Terry, , and M. Cummings. 2015. Regulating Healthcare Robots in the Hospital and the Home. *We Robot* (2015).

30. Sara Sorcher. 2016. The Internet of Toys raises new privacy and security concerns for families. (2016). http://www.csmonitor.com/World/Passcode/2016/0722/The-Internet-of-Toys-raises-new-privacy-and-security-concerns-for-families-video.

31. JaYoung Sung, Henrik Christensen, and Rebecca Grinter. 2009. Sketching the Future: Assessing User Needs for Domestic Robots. In *Proceedings of the IEEE International Symposium on Robot and Human Interactive Communication*.

32. Emmeline Taylor and Katina Michael. 2016. Smart Toys that are the Stuff of Nightmares. *IEEE Technology and Society Magazine* (6 March 2016).

33. Tammy Toscos, Kay Connelly, and Yvonne Rogers. 2012. Best Intentions: Health Monitoring Technology and Children. In *Conference on Human Factors in Computing Systems 2012 (CHI)*.

34. Ellen Wartella, Vikki Rideout, Alexis Lauricella, and Sabrina Connell. 2013. Parenting in the Age of Digital Technology: A National Survey. Center on Media and Human Development. *Northwestern University* (2013).

35. Svetlana Yarosh and Gregory D. Abowd. 2011. Mediated Parent-Child Contact in Work-Separated Families. In *Conference on Human Factors in Computing Systems 2011 (CHI)*.

36. Jason C. Yip, Tamara Clegg, June Ahn, Judith Odili Uchidiuno, Elizabeth Bonsignore, Austin Beck, Daniel Pauw, and Kelly Mills. 2016. The Evolution of Engagements and Social Bonds During Child-Parent Co-design. In *Conference on Human Factors in Computing Systems 2016 (CHI)*.