How do you Play with a Robotic Toy Animal? A long-term study of Pleo

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ABSTRACT

Pleo is one of the more advanced interactive toys currently available for the home market, taking the form of a robotic dinosaur. We present an exploratory study of how it was interacted with and reflected upon in the homes of six families during 2 to 10 months. Our analysis emphasizes a discrepancy between the participants' initial desires to borrow a Pleo and what they reported later on about their actual experiences. Further, the data suggests an apparent tension between participants expecting the robot to work as a 'toy' while making consistent comparisons with real pet animals. We end by discussing a series of implications for design of this category of toys, in order to better maintain interest and engagement over time.

Categories and Subject Descriptors
I.2.9 Robotics (Commercial robots and applications)

K.4.2 Social Issues

General Terms
Design, Human Factors

Keywords
Pleo, robotic toys, robot, home, children, long-term

INTRODUCTION

An area of increasing interest in the research area of Interaction Design and Children (IDC) is *robotic toys* (e.g. [19, 22, 31]). We define *robotic toys* as robots intended for basic leisure activities such as play, creativity, playful learning, entertainment, and relaxation. Importantly, robotic toys are *interactive* and have a software component, which distinguishes them from other mechanical or low-tech artefacts, e.g. those resembling the appearance of robots from fiction. Moreover, unlike a piece of software that is installed on a computer or a mobile phone, a robot is an active tangible artefact that interacts directly with the world around it. While robots have been used in industry for decades, and in the home for purposes such as vacuuming [e.g. 7], it is only recently that robots have become available for personal use among children.

One example of a commercial robotic toy that has recently gained interest among researchers [10, 21] is *Pleo* (by Ugobe), which takes the physical form of a baby dinosaur (see Figure 1). Pleo is interesting as a robot because like many toys, it does not prescribe a set of specific activities or games for the user, but instead encourages open-ended exploration and play. It is also different from most other toys as it is a fairly sophisticated device with a large range of sensors, motors, and advanced software components. This category of toys potentially pose new challenges for designers, partly as they are built for very open-ended interaction and also as their relatively high production costs advocate for a lasting long-term mode of interaction.

In this paper, we present the results from a long-term exploratory study of Pleo, where it was placed in the homes of six families for a period of 2 to 10 months. One of the goals of the study was to obtain a better understanding of the design challenges involved in developing advanced interactive toys for everyday settings.

BACKGROUND

In the area of IDC, a large number of *physical interactive toys and dolls* have been developed and studied, working as e.g. emotionally expressive input devices [18], for storytelling [30], or as support for children with sight impairment [11]. IDC further has a tradition in designing

Figure 1. Pleo with leaf and battery in recharger.

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and studying physical play kits aiming for construction play with robotic features. These include Electronic Blocks [33] that can be stacked and combined in different ways, various kits based on 'the Crickets' platform [20] (LEGO Mindstorms and Pico kit), and Topobo [19].

As Kaplan [14, 15] argues, robotic toys are designed to be 'useless' in the sense that they do not perform any tasks or services for users. Two early examples of commercial robotic toys were Furby and the ActiMates Barney. Furby was a rather simple toy, pre-programmed to 'grow' from speaking only its own language to advancing to English, and where Barney was a more complex animated toy that was designed to scaffold young children during interactive learning sessions with different kinds of media [26]. Besides being entertaining and taking the role as a playmate, Barney had a clear educational purpose.

In recent years, there has been a trend of developing robotic toys that look and act like *pet animals*. The Sony AIBO robotic dog (discontinued) and Ugobe's Pleo are well-known examples that were designed to be thought of as *artificial pets* or *artificial life forms*. Both AIBO and Pleo are claimed to develop a 'personality' and acquire new behaviours with time. *Paro* [23] and the *Huggable* [25] are two other example of robotic toy animals, with the physical appearance of a baby seal and teddy bear respectively. Both Paro and the Huggable are equipped with computation and sensors to be able to interact with people in primarily therapeutic or educational settings.

Below we provide a short description of Pleo as the object of our study, followed by a short overview of related studies of interaction with robotic toys.

Pleo

Pleo looks like a small dinosaur roughly the size of a cat, covered by a rubber skin over a mechanical frame. Internally, it has 14 motors with customised gears and force-feedback, which give it enough degrees of freedom to allow for tail-wagging, neck-positioning, mouth and eye-lid control, as well as a slow walking movement. It further has two speakers, a smaller one in the jaw and a larger one just above its tail. It also has a large number of sensors, including eight capacitive touch sensors, two infrared (IR) sensors (one on the nose and one in the mouth), as well as a small CMOS camera (also mounted on the nose). There are four optically interruptible push buttons (one for each foot), a tilt-sensor and two microphones positioned slightly below the eyes. The Pleo software runs on two ARM7 32-bit processors (a main controller and the other for image and sound processing) and four small 8-bit micro-controllers for motor control. External interfaces include an SD-card slot, Micro-USB and a hidden debug-port. Thus, compared to most other toys, Pleo is technically very sophisticated. Perhaps partly because of this, several research groups have recently shown interest in working with Pleo as a platform for research in interaction design [5, 21].

As a product, Pleo comes wrapped up in a green cardboard box along with a battery, a recharger, a small brochure, a green plastic leaf, as well as a unique ID card. The ID card is used to register the product and also allows the owner to start an online blog account tied to that particular copy of Pleo (see http://www.pleoworld.com/). A recent study of such blogs [10] shows that people take on a playful approach when describing their interactions with Pleo, e.g. pretending that Pleo is a live animal. Because of its life-resembling properties, Pleo has also gained interest among psychologists who have conducted experimental studies on e.g. how people interact with Pleo when given a specific task [16].

Out of the box, Pleo is programmed to go through three stages of development: 'hatching', 'infant' and 'juvenile'. The first two stages are usually completed within the first hour where Pleo slowly starts to move and interact with its surroundings. It then stays in the juvenile phase for the rest of its 'life', where it will interact with its environment and user according to its internal 'motivational model'. In use, the playing time is about one hour for a four-hour charge.

Pleo was initially created by the US-based company *Ugobe* and introduced in late 2007 at the price of 350 USD. Currently *Jetta Company Ltd* (http://www.jetta.com.hk/) owns the rights for Pleo, and has recently released an updated version.

Studies of robotic toys

In several past studies, robotic toys has been framed in terms of 'socially interactive robots' [6], 'social robots' [2, 3, 12] or 'relational artifacts' [29] where it is the social interaction between user and robot that plays the key role in for instance play, education, and various therapeutic settings. Kahn et al [12] describe social robots as "*robots that, to varying degrees, have some constellation of being personified, embodied, adaptive, and autonomous; and that can learn, communicate, use natural cues, and self organize.*"

When it comes to previous user studies of robotic toys, most have so far been lab-based studies of the psychological aspects of the interaction, or performed in institutional settings as part of a specific educational or therapeutic agenda. AIBO has been the object of a number of behavioural studies, where adults and children have been asked to reason about AIBO, interact with it in short sessions, and sometimes compare it to a stuffed animal toy or a real dog [8, 12, 17, 31]. These studies have shown that although children talk of AIBO as an artefact, they still talk *to* AIBO and interact *with* it as if it were a real dog [12]. The same appear to be true for adults, based on analysed posts from an online forum about AIBO [8].

Turkle et al [29] have conducted a longitudinal qualitative study of children's and seniors' relationships with AIBOs and Paros for therapeutic reasons in nursing homes, schools and homes. They found a tension between participants who

got very attached to the robot, treating and talking to it almost like a live pet or person, and participants who were openly very sceptical to forming a relationship with such an artefact. Based on the study, Turkle et al suggest that these kinds of robots could be valuable because they evoke questions about ourselves, such as what it is to be alive, to feel emotions, to love.

Tanaka et al [28] and Kanda et al [13] have conducted quantitative studies in schools with small humanoids (QRIO and Robovie respectively). Both studies ran for about two months, comprised of shorter experimental sessions of interaction with the robots. Kanda et al [13] report how the child-robot interaction changed over three phases in the study – decreasing considerably with time. Although this study was conducted in the children's ordinary school environments, the approach focused primarily on specific quantitative measures such as frequency of interaction. Moreover, as was only one third of the children who continued interacting with the robot throughout the study, and it is thus interesting to look deeper into the qualitative aspects of interaction with these kind of artefacts.

Further emphasis on more open-ended user studies of robotic toys may be relevant also as IDC as a field has a tradition of emphasising the importance of basing new designs on children's existing play practices [see e.g. 1, 4]. Previous studies in more general settings have for instance shown how children often move in and out of, and between different activities, and how toys are commonly transferred physically as well as imaginatively between different contexts [24, 32]. We see this as an important framing for the present study, as we aim to investigate a robotic toy as it is played and interacted with casually in home environments.

OVERVIEW OF THE STUDY

The aim of this study was to openly explore how a state-of-the-art robotic toy, Pleo, is interacted and played with on a casual basis, as well as how it is regarded by families in their homes over a prolonged period of time. In addressing this goal, studying an existing commercial product could be seen as an important complement to a priori studies where people reason about their desires and expectations of the interaction. Furthermore, robotic research prototypes are often not suitable for long-term studies in naturalistic environments. Such prototypes are by nature not sufficiently tested in terms of safety standards, are usually expensive to build, and prone to breakdowns. We argue that studying a commercial robotic product can still provide useful knowledge for robotic research in general, and shed light on challenges that arise when studying everyday use of what in fact can be referred to as a social robot.

In the following section we will present the study, including the selection of participating families and study procedure, and an overview of the collected data.

Participants

Six families participated in the study for 2-10 months and were lent a Pleo to keep in their home. To recruit people for the study, we used printed postcards that we distributed at a culture centre in the city, as well as at the reception desk at our research institute. The cards contained a link to a web-based form, which allowed interested people to choose among three different robotic toys to keep for a few months time for a research study of interaction with new technology. The participating families were selected based on showing interest in Pleo as opposed to the other suggested robots; having children of a varied age range; living within a reasonable travel distance from our research lab; and agreeing to be interviewed in their homes.

In the following we will briefly introduce the six participating families (the contact person for each family is in marked in italics):

Family 1 consists of a *father*, mother and two sons aged 10 and 14, and a dog. The family already owns several robots and related home electronic devices: a Roomba (www.irobot.com/), a Nabaztag (nabaztag.com) device, and previously an AIBO. They had Pleo for 3 months.

Family 2 consists of a father, mother, a 17-year old *daughter* and a 12-year old son. They kept Pleo for 2 months, and handed it back at the first interview.

Family 3 consists of a father, *mother*, and three sons (5-12 years old). The family has a hamster. They had Pleo for 10 months.

Family 4 consists of a *father*, *mother*, a 4-year old daughter and a 1-year old. The family already owns a Roomba. They had Pleo for 9 months.

Family 5 consists of a *father*, mother, an 11-year old son and a 6-year old daughter. They had Pleo for 9 months.

Family 6 consist of a *father*, mother, a 5-year old boy and a 3-year old daughter. They had Pleo for 3 months.

As it was voluntary to participate, this affected how long each family wanted to keep Pleo. For example, Family 1 did not wish to keep Pleo after three months because it disturbed their dog, and therefore forwarded it to Family 5 whose children they thought would enjoy playing with Pleo. We believe that the flexibility of the length of the study was necessary, as each family approached Pleo differently. However, what is important to stress here is that all participating families still had Pleo in their homes for at least two months, which has been argued is the minimum required in a long-term study that aims at observing ordinary use beyond the 'novelty effect' [27].

Study procedure

There are obvious methodological challenges when conducting studies in people's homes, such as the difficulties to do observations because of privacy and practical reasons. In order to address this we decided to

encourage the families to self-report using video about parts of their experiences with Pleo, in combination with semi-structured interviews. As we were interested in qualitative data and not measures of e.g. the frequency of interaction with Pleo, this seemed as a practical and appropriate approach in this study. We also hoped that this would make it feasible for the families to fit the study into their busy lives and thus participate a long time, as we did not want to overburden them with reporting or tasks to fill in on a regular basis, or too frequent interview sessions. We further wanted to provide an open study setup where the participating family members were allowed to reflect freely with one another before they were interviewed by us. Finally, we hoped that self-reporting in combination with interviews would address the well-known challenges of interviewing children.

Together with a Pleo robot (fully charged but wrapped in its original box), each family was equipped with a video camera to share personal accounts with us. They were told to film anything of interest to them, and were encouraged to particularly film play sessions with Pleo. To avoid that we would affect and guide their first impressions and interactions, the families were asked not to open the boxes until the researchers had left, and thereafter they would be allowed to interact with Pleo as they pleased. Each family was interviewed at least once and most of them twice about having Pleo in their respective home. In one case we asked the parents to interview their own children as a supplement, as we found it problematic to interview such young children. The semi-structured interviews were video recorded and between 20-45 minutes. The first set of interviews were conducted after lending out Pleo for approximately two-three months, and the second time after roughly five months. Since the families did not participate equally long, we had to be flexible about when we interviewed them the second time. This also had to do with fitting a home interview into their busy family lives.

Overview of the collected data

Our collected data consists of a combination of interviews together with video clips and pictures generated by the participants between the interviews. The participants tended to take photos and videos only at very the beginning of the study, so the interview material became the main source for later analysis. Having an exploratory approach meant that we were open to whatever emerged as prominent in their interaction, play and understanding of Pleo. The interview material was therefore transcribed and analysed in combination with the videos and pictures by repeatedly going through the data to find reoccurring themes and issues and also conflicting ones.

RESULTS

A first and very apparent observation when going through the material, and which contributed to how we chose to organise the data in our analysis, concerns the many different ways Pleo could be understood, including: 'Pleo as a robot', 'Pleo as a social mediator', 'Pleo as an object of tinkering', and 'Pleo as an artificial life form'. Interestingly, none of the families referred to Pleo as a 'companion' or 'friend', which is why we have chosen to avoid that terminology. Eventually however, one major tension that seemed to affect their engagement with Pleo was the initial assumptions made on *Pleo as a 'toy'* vis-a-vis *Pleo as an alternative to a live 'pet'*.

There are several reasons why Pleo could be anticipated as something comparable to a live pet. First, all of the families spontaneously made comparisons between Pleo and a pet animal in the interviews, a comparison that has also been reflected in previous experiments [31]. Second, Pleo belongs to a category of commercial products that can broadly be spoken of as 'electronic pets', and one of its major selling points has been that – like a living being – it is said to be capable of developing into a more complex and responsive entity with time. Third, half of the families (Family 2, 5 and 6) explicitly said that one reason why they got interested in Pleo in the first place was because they cannot have real pets (e.g. due to allergies) and were curious about Pleo as a potential alternative.

After several iterations of analysing the data, we found that the tension between approaching Pleo as a *toy versus a live pet* was reflected throughout the families' accounts of how Pleo was interacted with over time. Three main themes also emerged from the material where this tension is visible, and we have therefore chosen to structure our results according to these themes:

- Play and interaction
- Development and 'life cycle'
- Maintenance

We are aware that the themes are not exclusive and that they intersect, but we see this as an indication of the complexity as well as openness of robotic toys like Pleo.

Play and interaction

The first theme that we would like to bring up concerns how the participants played and interacted with Pleo, beyond the novelty effect. We are aware that both play and interaction are ambiguous terms with several and overlapping meanings. Here we refer broadly to participants' direction towards the artefact as an engagement similar to playing with a doll or live pet.

In the initial stage of the study we observed similar interactions as in previous short-term studies of robotic toys such as AIBO [8, 12, 17]. This includes how some of the children gave Pleo nicknames (e.g. "Mini-Dino"); adorned it with different items (e.g. a scarf); petted, tickled and touched it; talked to it; and created a special place or assigned things for it (e.g. a 'sleeping hut' or bed). In the beginning of the study, some of the participants also brought Pleo to their school, kindergarten or office to show friends and colleagues, and two families reported having it

Figure 2. Girl and boy playing with Pleo for the first time.

on display at parties, potentially to impress their friends or just to see their reactions. However, our study provided a different picture regarding the long-term interaction. We learned from the interviews that our participants did not interact with Pleo in any regular manner. It was played with in the beginning, but after that it was not used at all, except for special occasions such as when friends visited. As shown below, the general excitement soon wore off and left the participants – children and adults alike – puzzled about how Pleo is supposed to be interacted and played with.

First, however, we will look at an excerpt from a video clip of the boy and girl in Family 5, as they encountered Pleo for the very first time. Both children are sitting on the floor with Pleo between them, and the boy is holding a small paper card in front of Pleo, trying to get Pleo to see the card and take it (see Figure 2). When Pleo does not give any signs of taking the card or moving towards it, the boy finally puts the card into Pleo's mouth. Next, he throws the card on the floor about 20 centimetres in front of Pleo:

Boy: "Fetch!"

[They wait for a couple of seconds. The girl who is sitting behind Pleo is about to touch it]

Boy: "No, L [girl's name]. He should be a little on his own. Fetch! Get it, get it, walk here… walk here… [points at the card] Walk to me, come here… [claps his hands] Now you get […] Come, nice dinosaur, nice dinosaur, nice, nice…"

[Pleo is not moving. The girl discreetly starts to push Pleo in the direction of the card. Finally she pushes Pleo all the way and the boy gives the card to Pleo.]

Boy: "Ah, bravo!"

Girl: "I pushed it all the way, so that it could go there…"

Boy: "Nooo…"

The clip captures how the children in different ways are exploring how Pleo could be interacted with, and what it could do. In their initial interaction, it seems that they are drawing upon their knowledge and imagination of pets, for instance dogs, and how it may be possible to interact with them. As with a dog, they are exploring whether Pleo is able to perform tricks such as responding to the command 'fetch', and interpret this as referring to the object recently thrown on the floor. As Pleo does not respond in the way they had expected, the children need to work around this, first by manually placing the card into Pleo's mouth, by talking and clapping hands, and later by manually pushing Pleo in the direction of the card. To sum up, the children were looking for Pleo to attend to objects.

The excerpt also exemplifies capabilities that the participants initially had expected to find in Pleo such as walking and attending to objects and sounds. After the early exploration, the families soon learnt that Pleo does not walk much and neither respond to sounds or requests, which came to affect their engagement in Pleo in the longer run. At the end of the study the boy in Family 5 explains to us:

"*We haven't **played** much with it, we have just petted it… and watched how it's reacting… like when it sang one day… and when we started to insert those things [memory cards with different behaviours] it got a little angry sometimes.*"

When the interviewer asks the boy to try to describe what they have been doing with Pleo, he answers:

"*I have mostly petted it… I really don't know how to play with it. [giggles] It really doesn't work to throw a ball. **That** doesn't work… […] Petting it. I usually take it slow because it doesn't do much, maybe I put something in its mouth…*"

The boy's comment captures how our participants described interacting with Pleo after the first excitement had worn off. They generally phrased this as too limited for what they had expected or wished to do, which seems to be more physical, active and varied play. As the father in Family 4 said:

"My feeling is that it is more important that he interacts with you, than that he has X, Y, Z motors and can wag his tail in 28 different ways. It would be better if he could follow one's gaze and that the software was sharper."

In fact, the majority of the participants were concerned about and surprised at Pleo's inability to move. They reported that rather than walking from A to B, it takes a few steps or simply moves parts of its body but remains in one spot. As one parent said, this behaviour goes against the dynamics of real animals, and makes interacting and playing with Pleo rather limited and monotonous. One boy was very fascinated by how Pleo does not bump into obstacles – this was his favourite part of Pleo – and he explained to us that this is possible because Pleo has a camera mounted on its nose and that "*is its vision*". Despite this, he was disappointed that Pleo rarely walks at all, how it is very limited and non-active, and that this eventually made Pleo nothing but a *"rather boring toy"*.

It is worth stressing that Pleo does in fact have the capability of walking, although our participants did not experience this. To make it walk, you would need to take a more passive approach and leave Pleo unattended for some time. However, this was simply not the way the majority of the participants interacted with it during play sessions, as their interaction was predominantly active, involving various forms of touch and sound. When Pleo did not react according to what they had envisioned, they switched it off to play with something else.

Another way that Pleo could be interacted and played with is by downloading new software pieces from pleoworld.com to a memory card and inserting it into Pleo to change its 'behaviour'. Some of the families tried this in the beginning of the study. For example, Family 5 downloaded a Tyrannosaurus theme, a Christmas theme, and a Halloween theme, which gave Pleo new noises or songs, or slightly changed its movement pattern. On the one hand, the children seemed to enjoy the tunes and noises – such as 'ghostly cries' in the Halloween theme and jingle bells in the Christmas theme. On the other hand, they said that the sounds are simply repeated over and over again and that they grew tired of them after a while. As the boy said, "*You can't stand that many Christmas songs in a row…*" What this meant was that these updates allowed a fun change for a short while, but nothing that the participants seemed to incorporate or could build upon in their long-term interaction.

At a more technical level, the fathers in Family 3 and 4 and the 17-year old girl in Family 2 also expressed expectations of being able to tinker more with Pleo, like changing its behaviour more thoroughly or even reprogramming it. The girl explicitly explained that her interest in Pleo was in its technical properties, rather than play, and that she had wanted to explore these in more detail.

Other factors that affected the interaction came into play as well. Some participants, like the parents in Family 6, were worried that that the machinery could break from violent play, so they would not let their children play unsupervised. Afterwards, the father reflected that this possibly might have affected his children's interest in playing. Also Family 1 was worried that Pleo might break, especially since the dog reacted very strongly towards it. They therefore did not leave the robot alone with the dog, and eventually decided to hand it over to some friends (Family 5). Finally, the 17-year old girl in Family 2 did not want to leave her younger brother unattended with Pleo since she was afraid that he might break it.

To summarise the participants' interaction and play over a long time, they initially had (very) high expectations of what they thought was possible to do with Pleo, which they learned could not be met. One parent had thought that "*it would be more 'complete'. That it would be more like interacting with an ordinary animal*." While the adults expressed this insight in terms similar to the previous quote, the children talked more of Pleo in terms of being boring, noisy, and lacking action. After the initial enthusiasm and discovering its limitations, the families reported that Pleo was treated like any other regular toy. This meant that the children played with Pleo when they felt like it, for instance in pretended play sessions in a similar way to other toys such as teddy bears and dolls, which happened occasionally rather than on a regular basis. Exceptions were the 3 and 5-year old in Family 6 who did not play with Pleo at all. The 3-year old daughter was even afraid of Pleo in the beginning, possibly because it can look very 'real'. Although the parents attempted to make Pleo look attractive by turning it on and keeping it near the children in the living room, they simply seemed to prefer watching TV.

Moreover, the participants' confusions regarding how to play with Pleo indicate that 'playing' with a toy seems to imply something different to 'playing' with a live animal. With a toy, simply pretending can usually be enough to be considered playing. With a real animal, playing seems to mean a more concrete form of interaction, where actions and instant feedback is expected from the pet. The basic petting that Pleo primarily supports is likely to have contributed to become an obstacle in play, when being compared to a live animal.

Development and 'life cycle'

The second theme concerns how the participants experienced Pleo's 'development' from 'hatchling' to 'juvenile', and how Pleo fitted with toys in general and the ways these are played with over time.

Most of the parents and children were initially very curious about exploring Pleo as a means of catching up with technology development and seeing what robots can do – the promised 'development' in Pleo played a large role in triggering this curiosity. It became clear that they had expected Pleo to be able to learn and develop. These expectations were strongly influenced by what the participants had read in the folder that came with Pleo and on pleoworld.com. The excerpt below from the mother in Family 4 captures some of these expectations:

"*It was going to be fun to see how he developed, and he didn't, he's just a stupid machine that walked around and nothing much happened, he did the same things, and sounded the same, made the same noises*."

Importantly, the 4-year old daughter in Family 4 seemed to play with Pleo in a more uncomplicated manner, treating it as a toy animal among her other toys. The parents' expectations of 'development' thus seemed to be based more on how Pleo was framed and marketed, than on any demands or expectations from their children. A related observation concerns how the participants expected Pleo to develop *quickly* from 'hatchling' to a more complex 'being'. As one father said:

"*You turn him on and then it is nothing more than a toy. It didn't improve at all. The first time it really didn't do anything for the first 45 minutes…*"

We think that this concern about time is remarkable as it is unlikely that one would have the same concerns about a real pet. It is apparent that this participant not only had high expectations on Pleo's development, but also that it should happen fast because it is an *electronic* pet. In this study, none of the participants reported that they had observed any long-lasting change in Pleo during this extended period of time, which resulted in an overall disappointment in the lack of development in Pleo.

The interviews further raised a number of issues regarding how Pleo might fit in with children's play patterns. As the parents in Family 1, 3 and 4 suggested, there is a '*life cycle of toys*', which is likely to apply to Pleo as well. This not only means that children change interests as they grow older, but also that they frequently simultaneously attend to different toys or themes of toys, and that they shift between which ones are their favourite toys. We see this as a highly relevant observation from the perspective of designing advanced, and expensive, toys.

Related to the life cycle of toys was also Pleo's ability to fit in and 'belong' to the existing 'eco-system' of toys and resources in the homes. The father in Family 1 explicitly noted that his sons would probably have enjoyed Pleo more if they had been more into dinosaurs, which they all had been earlier. By now, his youngest son was more interested in space and the father suggested that any robotic toy aligned to that theme would probably have had a better chance of gaining popularity in this family at the time of the study. Similarly, it was no coincidence that the participant who took on Pleo the most (the 5-year old in Family 2) was playing with a range of other dinosaur and monster-themed toys at this period of time. Therefore, whether a toy 'works' for playing appears to be subjective and dependent on the existing context of playing, and not only on the capabilities or features of a particular toy. An aspect that was noted in most interviews was the issue of the noise that Pleo makes (both from motor movement and from speakers), and how that did not always fit into the social environment of a home.

Maintenance

The third and final theme concerns an activity around Pleo that emerged as very central in this study – namely that of maintaining it and simply making it work. The maintenance not only involved recharging batteries but also various efforts in trying to make Pleo develop. This included downloading and installing programs, as well as actually spending time interacting with Pleo to make it develop.

In the excerpt below, the parents in Family 4 reflect on their role in making Pleo more interesting to their daughter:

Mother: "*That little folder [that comes with Pleo] made it sound much more interesting than what it really is.*"

Father: "*Then you ask yourself, what are we doing wrong?*"

Mother: "*Yes, exactly. Do we have it on too little? Should we sit and interact with him more? What should we do?*"

Father: "*Yes exactly, like when you were home with M [the toddler] during the days, and you switched Pleo on and play just so that he could develop.*"

Mother: "*And then like what is this? Nothing happens. He is just as stupid as a week ago, he still walks only backwards. He still only takes just a step forward and "uuuuhh" is the only thing he can say. Then you lose interest. No, I really made some good efforts there during some weeks.*"

Father: "*You did that so K [the daughter] would have some higher experience when she got home [from kindergarten], something new and more fun.*"

For some time, the mother thus explored different strategies in order to speed up the development in Pleo, so that the daughter would find it more stimulating. It seems that this mother was putting considerable efforts in both trying to make Pleo develop, and staging it so that it would seem more 'real' to the daughter. These parents also seemed to think that Pleo demanded too much of such 'staging' for the amount of play and company it could offer to their daughter.

The parents' role in this setting could be looked upon as 'backstage technicians' in their children's play. When reflecting further upon this, the mother said: *"you want some value for your money, right, otherwise it just sits there and collects dust"*. From these and similar statements from other parents, it seems that the parents sometimes felt a responsibility to engage in the maintenance of Pleo, perhaps because they know it is a relatively expensive device (even though they did not pay for it in this case).

Recharging Pleo became a time-consuming activity. The fact that Pleo allowed only one hour of play but required four hours to recharge frustrated adults and children alike. It was also a nuisance that there was no way of telling when the robot was going to run out of battery, and that you actually need to remove the battery from Pleo to recharge it. When reflecting upon this, several parents compared Pleo with regular home appliances and how even a simple electronic toothbrush can recharge itself without the need of removing the battery. We got many suggestions about how this could be improved and made more 'integrated' into playing with Pleo. For instance, recharging could be done simply by putting it in a special bed, similarly to how Roomba has a docking station for recharging.

The fact that the battery needs to be removed from Pleo also became a serious obstacle for play in another way. It was revealed that Pleo was not really possible to play with when it was switched off. We find this very interesting, as many other physical toys can be played with regardless of whether they have batteries in them or not. Apart from not

functioning as an interactive device, the fact that Pleo froze and became unpleasant to handle and play with when it was switched off or when the batteries had run out, disturbed the children in their play experience. Furthermore, the mechanics inside the robot made noises when moving the robot in off-mode, which made the participants worry that they might break it.

Finally, regarding Pleo as an electronic pet, one father said: "*It doesn't deliver to 100% [as a substitute to a real pet]… I mean, it lasts for maybe an hour and then it needs recharging…*" We think that this is interesting as a more general issue, especially considering the efforts that people are willing to invest into real animals and other hobbies. Compared to the efforts put into e.g. walking a dog, recharging a battery now and then may seem a trivial duty. However, as an electronic device, this kind of maintenance was difficult for the families to accept.

DISCUSSION

Similarly to what behavioural studies of robotic toys have suggested previously, our participants did in several ways treat Pleo as if it were a real animal, e.g. by petting it, giving it names, and displaying emotions towards it [8, 12, 17, 31]. However, our study also showed that these activities do not seem to be enough to keep a *long-term interest*. Instead, Pleo was generally treated as a toy, which implied that the children who did play with it, did so only for short periods of time and then put it among their other toys to start playing with something else. In that respect, Pleo failed to encourage the regular interaction that is assumed by the price and sophistication of this robot, as well as by the concept of 'interactive companions', as promoted by some strands of robotic research. Rather, Pleo was played with when the children wanted to, otherwise it sat somewhere and '*collected dust*'.

These insights lead to the question of what actually could build up a long-term interest in an interaction with these kinds of robotic artefacts. Based on our study, we have identified a series of *challenges* based on the analysis presented above.

Regarding general interaction and play, one challenge is to design for a more active mode of interaction that more closely matches the modalities suggested by the appearance of the device. Although nearly all participants in this study were indeed fascinated by the way Pleo reacts to touch, and praised how its detailed movement pattern looks very 'real', it was still clear that they would have preferred Pleo to be more interactive and reactive during those sessions. This concerned not only its physical ability to move, but also its ability to react to sounds, follow objects, come when you call its name, etc. In that sense, the lack of active and explicit forms of interactive features seemed to overshadow the more subtle forms of interaction that Pleo did in fact perform. This study indicates that both adults and children were puzzled about how Pleo should be played with due to its current limitations and un-articulated modalities. Importantly, and in contrast to low-tech toys and dolls, the expectations here seemed to be also concerned with the performed skills of the robot, rather than relying only on one's own imagination.

Our interpretation of this is that this category of robotic toys should be able to act and perform, but *in response* to people's actions rather than autonomously. It is important to stress that this would not imply that it should be designed for more continuous play, but rather to make its perceivable actions and state more concretely connected to the actions performed by the user. Thus, the participants wanted to be active in playing, but also that Pleo would be similarly active in responding to these actions. The 'skill' of being able to attend to objects or sounds exposed to the robot was for instance something that the participants expected the robot to perform actively. With another kind of toy, it may not have been a problem to claim that it 'sees', but several parents in this study seemed to take such information more literally as technical features. This perhaps especially due to the presence of eyes and a visible camera, together with expectations of capabilities set by media and fiction. For the children it was rather factors such as the short battery life and lack of action that became true obstacles in their play with Pleo.

A related concern is how changing Pleo's behaviour using the SD card became a central part of the interaction in some cases, and also the mode that some of the children found the most interesting. This relates to the central aspect of *tinkering* that other robotic toys and play kits such as the LEGO Mindstorm, Topobo [19], and the Sony AIBO invite. For instance, despite the research focus on AIBO as a toy for children, one of its main actual uses was for engineering students to prepare robot teams for the annual RoboCup championships (http://www.robocup.org/). We suggest that there might be some inherent expectations on robotic toys regarding tinkering, i.e. that one should be able not only to play with them as they are, but also to access and modify their behaviours on a more technical level. Interestingly, this aspect of robotic toys has not been much emphasised in previous user studies of electronic toy animals, and thereby suggests an intriguing area for future work.

Regarding development and life-cycle, a general challenge concerns the catering for realistic expectations regarding how toys are used more generally. This may seem a trivial guideline as no one would expect a designer to strive to *not* meet their users' expectations. However, an important insight from this study was the discrepancy between the reasons for the participants' initial desires to borrow a Pleo robot and what they reported later on about their actual experiences. Essentially, they had very high expectations for the level of intelligence and computational features, as well as of the level of basic technical robustness, and the study showed how Pleo failed to meet most of these.

This suggests that this family of toys may need to be better grounded in existing play practices and in the context of the

home. In the context of a home, a robotic toy may need to fit in a child's room and the existing set of toys that inhabit it, and also the changing nature of this environment. This could perhaps be addressed by structuring the context of playing, for example by informal communities of friends owning similar toys, or by aiming for a key 'role' among the child's toys as an artefact that is particularly good at triggering play, curiosity or fantasy.

Not only does the particular design but also cultural and societal influences play a role in creating expectations, perhaps especially when dealing with robotic artefacts. Given the broad cultural notions of robots (e.g. as action figures, science fiction characters, objects of tinkering, and characters in children's TV programmes), it is likely that robotic artefacts trigger more complex patterns of expectations than more mundane technology. Thus, we may need to put further considerations into how to meet existing cultural notions when designing robotic toys.

Regarding maintenance – a main challenge here was to make maintenance a more integrated part of the interaction and play. A basic reflection was that while the maintenance of a pet is part of the interaction (e.g. walking the dog), it is completely detached with Pleo (e.g. recharging). As opposed to the Tamagotchi (www.tamagotchi.com) that acts 'needy' in order to call for maintenance or care, Pleo simply stops working. This gap between play and maintenance was further emphasised as maintenance often was performed by another person than the one(s) actually expecting to play with it. In particular, this was true in the families with the younger children, where it was the parents who had to cater for the maintenance while the children only 'played' with Pleo.

Although maintenance is a well-known research topic in information system research, and has been investigated in studies of technology such as networks in the home [9], it is seldom highlighted as a core challenge in interaction design for children. However, our study points out that in long-term settings, where end users unavoidably are required to engage in maintenance activities, these need to be addressed more explicitly as a property of the interaction. In this study, the level of effort required to prepare, update and recharge the robot did not blend seamlessly into the ordinary play patterns in these families.

To sum up these challenges, we were indeed surprised to see that these fundamental issues emerged as the most prominent themes in a study of a state-of-the-art commercial product; particularly since these issues have not been identified as central in previous related studies of interaction with robotic toys. However, considering the recent attention to Pleo commercially as well as in research, our study indicates that these design challenges nonetheless need to be taken into further consideration in the design of robotic toys.

CONCLUSIONS

As we initially argued, there is a lack of open and exploratory studies of robotic toys with a focus on everyday and long-term interaction. With this study, we have started to address this gap and made at least three contributions. *First*, our empirical data provides a complementary picture to previous studies of robotic toys. In particular, whereas previous research has focused on presenting colourful descriptions of imaginative play, our results indicate a more mundane confusion. Three themes emerged from the data: how the users *played and interacted* with Pleo; how users looked upon Pleo in terms of *development and life cycle*; and how basic *maintenance* became a central aspect of keeping and using Pleo. In these three themes, there was a clear tension between Pleo as a toy and Pleo as a live pet. We argue that shedding light on everyday accounts like these is necessary in order to fully understand robotic toys.

Second, we have presented a series of basic design challenges with regards to designing robotic toys for long-term interaction. Again, these design challenges focus on rather mundane issues, but issues that have not been identified previously in related studies of personal robots. We also believe that these aspects are not only relevant to robotic toys, but also when keeping a long-term perspective of technology use in general.

Third, this study points at new questions that are worth further investigation. Among others, we suggest that one such area is how some people look at and interact with robotic toys as objects for tinkering and lightweight construction play, and how such relationships with robotic toys could inform the general design of such. Another key area that needs further exploration is what expectations people have of robotic toys e.g. from culture and the society, along with what expectations *we* as researchers and designers have of the same artefacts.

Finally, we would like to emphasise that our goal with this study was not to focus on the shortcomings of Pleo, but to provide an increased understanding of the challenges involved in designing for open-ended play with interactive artefacts for an extended period of time. By highlighting these challenges, we hope to provide pointers for designers and engineers, avoiding some potential pitfalls in the design for long-term interaction and open-ended play.

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