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This is the authors' version. To cite this paper:

Manches, A., Duncan P., Plowman L. & Sabeti S. (2015) Three questions about the Internet of Things and children. *TechTrends* 59 (1) 76-83.

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Abstract

Children's interactions with technology are evolving and devices that can capture and respond seamlessly to their everyday activities are increasing. This raises questions such as: i) how these technologies shape children's activity; ii) how the data from their activity is used, and iii) to what extent children, and their parents, are cognisant of the technology. This paper examines these questions in light of the Internet of Things (IoT) by drawing upon three investigations (desk-based, home context, school context) using two commercially successful IoT designs (Activision Skylanders/Disney Infinity). Whilst these particular games are limited in what activity they capture, the research illustrates how the digitisation of everyday objects such as toys can influence both attitudes and behaviour, and generate potentially revealing data about children's everyday activity. Parents and children appear to have a low level of awareness, but the research also showed children's potential, with support, not just to understand, but design with this technology.

Keywords

- Children
- Internet of Things
- Toys
- Video games
- Interaction
- Digital Technology

1. New forms of interaction with technology

The ways in which children are able to interact with digital technology are evolving. Interfaces and devices such as the mouse or keyboard, which have typically excluded those younger than around five or six (Donker & Reitsma, 2007), are being replaced by more direct, embodied, forms of interaction such as touchscreens or gesture recognition devices.

There is also an increasing number of devices that capture a wider range of children's interactions and behaviours. *KidFit*[1] for example is a wearable wristband fitness tracker able to capture and respond to children's physical activity. *hereO* is a watch able to inform parents of their children's location. *Sprouting baby monitor* captures and provides feedback about children's sleeping patterns.

By encouraging comfort, safety or exercise, the stated aims of these devices are laudable. However, it is timely to reflect on some of the challenges presented by these devices. The extent to which the device influences children's behaviour, the uses to which the data generated by these devices is used, and whether children are aware of, and can consent to, use of the technologies with which they are interacting are all issues that demand consideration.

[1] URLs for all products are provided after the references.

As new technologies are designed to capture and respond to children's everyday experiences more and more seamlessly, perhaps we have to accept that a possible trade-off is diminished awareness of the influence of these technologies and the value of the data being captured. As we witness technologies becoming increasingly integrated into children's lives, there is greater need for critical reflection.

2. The Internet of Things (IoT)

The Internet of Things (IoT) exemplifies the ways in which digital technology can become embedded into our physical environment. According to Pacual-Espada et al (2011), the idea behind the Internet of Things is that any 'thing' or object that is appropriately tagged (e.g. through RFID or Radio Frequency Identification), is able to communicate through an internet-like structure with other objects that are similarly tagged.

The IoT can link typical activity with an everyday 'thing' to a wide range of other activities. For example, removing a carton of milk from the fridge could result in new milk being ordered online. Approaching home by car could trigger the kettle boiling.

According to Ng (2013) every activities (such as making the tea) involve patterns of interaction around different things. Connecting objects through IoT therefore generates exciting commercial opportunities, and the potential to disrupt how we interpret and interact with our physical environment. A kettle boiling may offer a sign of an approaching partner; taking milk out of the fridge may lead to thoughts about what other food needs ordering.

2.1. IoT and Children

'Things' play an important role in children's lives. Particularly for younger children, everyday activity is often centred on physical materials such as toys. Whilst there exists a range of digitally augmented toys for children (Plowman & Luckin 2004) and associated research (Manches, 2013), the digital effects of children's interactions with (for example) lights or sounds are typically constrained within time and space to direct manipulation. With IoT, children's interactions with things such as toys can be linked to a wide range of previously distinct activities.

The potential of IoT for children is already being explored. *Teddy the Guardian,* for example, is a digitally augmented soft teddy bear that can capture and communicate important "health parameters like heart rate, oxygen saturation, body temperature, and stress levels". The bear is intended for use in hospitals to communicate this information to health professionals, significantly reducing children's anxiety commonly associated with traditional tests. Products such as *Teddy the Guardian* prompt three key questions about the IoT in the context of use by children:

2.1.1 How do IoT devices influence children's interpretation of, and interaction with, everyday things?

Linking familiar activities with things to other activities may influence how children interpret and interact with these things. With *Teddy the Guardian*, children may continue to see the bear like any other soft toy. Or hugging the bear may simply be re-interpreted as another health activity. Alternatively, it is possible that new forms of interaction arise that bring together children's experiences of different activities. Children's knowledge of the bear's link to health services may influence their perceptions of the bear as a protector (indeed this is implied in the product's name). This may influence a range of behaviours such as wanting other toys to hug the bear, extending its protective role into their everyday play.

2.1.2 How is the data that is captured by IoT devices being used?

The IoT is able to capture data on children's interaction with things. The biometric data gathered by *Teddy the Guardian* is used by health professionals but it is not difficult to imagine the value of the data to others, from health companies to parents. Other IoT devices may capture less intimate data, but could nevertheless provide unique insight into children's everyday activity. It is important to question how such data is collected and used.

2.1.3 How cognisant are children and their carers of IoT devices?

The nature of IoT is that everyday things become interfaces for digital technology. As technology becomes more seamless, children may become less aware of how their actions are being captured and used. Without explanation, children may be unaware that hugging a teddy is providing a range of adults with intimate knowledge of their biometric data. Clearly, parents need to be informed if they are to give consent on behalf

of their children but the public's awareness of the implications of the IoT for data protection is currently quite low.

2.2 Contribution of paper

The contribution of this paper is to draw attention to the three questions about IoT and children presented above. We start the process of addressing these questions by drawing upon recent research on a manifestation of the IoT that has been integrated into the lives of many thousands of families who do not have full knowledge of the implications of the technology for their day-to-day lives at home.

3. Research background

3.1 IoT Toys: Activision Skylanders and Disney Infinity

Toys that are tagged and can be used to interact with a dedicated video game are described here as 'IoT toys'. Two such examples are the commercially successful video games Activision Skylanders and Disney Infinity.

Figure 1: a) Skylanders and b) Disney Infinity figurines

Both Skylanders and Disney Infinity consist of plastic figurines (Figure 1) that when placed on a portal (plastic base) result in a corresponding virtual avatar being selected within the game which children can subsequently control in a typical fashion using a game controller. It is possible to place more than one character on the base depending on the system and particular game selected.

In both games, the base is connected to a games console (Xbox/PlayStation/Wii) by a USB cable and holds an RFID reader concealed inside. By detecting the RFID tags on toys placed on the portal, the game offers children the appearance of the physical characters coming alive on screen. The games therefore bring together two forms of previously distinct activity: interaction with physical toys and interaction with video games.

Skylanders is marketed for children aged 8 and upward (and Disney Infinity for slightly younger children (7+ years). The games have been commercially successful: in February 2014, toy sales for Skylanders reached 175 million units, while their franchise revenue was a staggering $2 billion[2]. Disney Infinity has generated approximately $500 million in retail sales globally since its launch in August 2013 and in January 2014 had sold

[2] http://www.forbes.com/sites/greatspeculations/2014/07/03/activision-confident-with-skylanders-franchise-despite-tough-competition/

3 million starter packs[3]. These games therefore provide a significant real-world context with which to explore the questions raised in this paper about the IoT and children.

3.2 Design of the study

The preliminary findings reported here have emerged from research designed to explore these questions. The three main elements of the study were: a social media scoping review, fieldwork in children's homes, and a school-based design workshop.

3.2.1 Social media scoping review

Desk-based research was carried out on social media sharing sites and forums (e.g. YouTube, Google image search, Mumsnet). Searches were limited to user content generated by parents and children, not professional communications such as promotional material.

3.2.2 Fieldwork in children's homes

Fieldwork was carried out in children's homes and took place between March and August 2014, involving visits to the homes of 10 children (4-8 years old) across five households. Data were collected from parents and children through interviews, observations and drawing activities. Additional data were collected via photographs, video and audio recordings and interviews with parents. The methods used in the study were chosen based on their efficacy and suitability as evidenced in previous research with young children in the home context (Duncan, 2013; Plowman & Stevenson, 2013; Plowman, 2015).

3.2.3 School workshop

Two two-hour workshops were carried out with 10- and 11-year-old children in school. The workshops focused upon children's understanding of how the IoT video games worked, before and after explanation by the researchers, and how they applied this understanding to generating new IoT design ideas.

4. Findings

The questions introduced in 2.1 are reformulated here to make them applicable to the specific context of the study:

- How do IoT video games influence children's interpretation of, and interaction with, toy figurines?
- How is children's data captured by the IoT video games being used?
- How cognisant are children and their carers of the IoT video games?

The following section summarises the findings relating to each of these questions. The discussion of issues relating to children and the IoT is then broadened out in section 5.

4.1 How do IoT video games influence children's interpretation of, and interaction with, toy figurines?

This section looks at children's individual interaction with the IoT toys, interpersonal interaction with other children, and interaction between different environments.

4.1.1 Individual Interaction

With both types of IoT toys, the technology created a digital link between the physical objects and the on-screen game, bringing together two distinct activities: playing with physical toys and playing video games. The novelty of these linked activities is emphasised in marketing literature where children are seen to play the game whilst also holding the figurines. This type of interaction, however, was not evident in the fieldwork; instead children predominately used the figurines simply as a means to select on-screen characters.

Whilst children tended to use the toys just to progress in the game, this did not mean they did not value the physicality of the toys. When asked if they would be happy to play a screen only version of *Skylanders*, children insisted they liked the toys. The toys seemed to hold a status as a collector's item for children. This was suggested in the way children tended to line up their toys for display, sometimes even during gameplay (Figure

[3] http://www.computerandvideogames.com/461478/disney-infinity-starter-pack-sales-pass-3-million/

2). Comments on forums and clips on video sharing sites also support the idea that children were proud of their toy collection.

Figure 2 Skylanders toys lined up and displayed

Whilst our observations and interviews with children and parents emphasised the video game aspect of interaction, there were occasions when children interacted with the toys independently of video games. Sometimes this was simply a response to being prevented by parents from playing the video game (because they wanted to limit screen time, for instance); at other times it was the result of waiting turns when playing with a friend or instances of younger siblings finding the video gameplay too difficult. This suggests that more physical gameplay with the toys might be expected with younger users.

The use of Skylanders toys independently of the video game is also referenced in several blogs. For example, the following statement is commented alongside the image in Figure 3:

"With growing interest at what the next technological and gameplay step will be for the Skylanders, I find it more than a little ironic that my kids seem to spend increasing time playing with our collection of Skylanders figures away from the game." (Robertson, 2012)

Figure 3: Physical toy play (Robertson, 2012)

The question that frames this section asks whether the IoT video games influence the children's interpretation of, and interaction with, the toys. We found no evidence for this. Although one child said that he did not want to mix up his toys with a friend's (as each toy stores information about the level reached), there was no evidence in the fieldwork or desk-based research that children's interpretation, or interaction, with the physical toys was qualitatively changed as a result of the toys' link to video game activity. On searching the re-sale cost of used toys, there was no evidence that progress in the video game influenced the monetary value of the physical toy.

4.1.2 Interpersonal Interaction

Children often played the video games with a friend or, more commonly, a sibling. The ability to play with more than one character allowed children to play together, similar to other multi-player video games. Children

also played in single player mode, taking turns to control the game. The non-playing children would generally watch, although several Internet images show the non-video playing child to be interacting with the physical toys whilst waiting (e.g. Figure 4).

Figure 4: Two forms of activity (OC Mom Blog, 2012)

www.orangecountymomblog.com/2012/11/top-must-have-holiday-toy.html

Figure 4 illustrates the two forms of activity afforded by IoT games. However, children's physical interaction with the toys is only digitally linked to the video game when characters are placed on the portal. Consequently, one child's activity with the physical toys is not digitally linked to another's activity on-screen. Children's play would arguably be more collaborative if they were either playing the video game together or both playing physically.

The link between the physical characters and the video game did influence children's interpersonal interaction in one way. Almost all children physically manipulated the characters when talking about them, creating gestures with the character to describe gameplay. Children were also observed moving characters toward or away from each other: communicating turntaking. Although this communication was mainly with, or for, the researcher, actions and gestures around objects to support communication is documented in the literature (Roth, 2002). More extended observation would be able to explore whether children's physical interaction with toys supported communication with peers during everyday game play.

A final point concerning interpersonal interaction is the influence of the physical toys on parent-child interaction. The interviews drew attention to two main ways the physical toys initiated communication: parents have a more visible way to observe children's gameplay as the figurines are a material manifestation of what children were accessing on-screen. Secondly, children needed to purchase physical characters to proceed in the game. Buying these characters was typically carried out in a joint shopping experience.

Parents were generally positive about the toys, particularly with reference to their physicality, as they were able to relate these toys more to their own play experiences. They also noted their preference for seeing physical evidence of their purchases in contrast to virtual in-game purchases. The physicality of the toys offered parents more control in terms of knowledge of what they were doing and their role in prolonging the life of the game by buying new characters.

4.1.3 Environmental Interaction

As the toys could be used on other game consoles, several children described taking their characters to friends' houses to play. We were interested in exploring whether children played with the toys in various locations as they might with traditional physical toys. Most toys were stored near the game console, typically in the family living room and it is possible that the fixed location of the wired portal constrained the extent to which children interacted with toys in different places within and beyond the home.

The value assigned to the toys by the parents led to restrictions on where children could play with them. Parents were reluctant for the toys to be taken to school or to friends' houses but it was unclear whether this was related to their digital capabilities of the retail price.

4.2 How is the data that is captured by the IoT video games being used?

Similar to other video games, children's interaction generates data. According to Activision's privacy policy (http://www.activision.com/legal/privacy-policy) use of Activison Property permits the company to "collect, process, and combine data such as your age, gender, interests, name, email address, gameplay, marketing preferences, customer service, and device-related information (like your IP address)". The policy also states that "Activision does not knowingly collect or store any personally identifiable information such as name, address, or e-mail address from children under 13". Although this is not unusual in the terms and conditions of video games, a key difference here is that Activision's *Skylanders* uses children's behaviour with a physical toy, albeit the simple act of placing a character on a base, as a source of data. Yet this physical extension of data collection may be telling as, for example, the same toy placed on two bases reflects the child's physical movement between locations.

4.3 How cognisant are children and their carers of the IoT video games?

Although there are various online discussions of how the IoT toys work, in our research there seemed little reflection from parents or children unless prompted. When asked, children and parents tended to refer to the bases scanning the objects as having similarities with scanning barcodes in a supermarket. One child pointed to the numbers on the base of the toy that were being 'read'. When this child was shown that the bases could detect toys through a magazine, they became fascinated with the technology. A five-minute exploration of the technology culminated with the child finding out that tin foil blocked the RFID communication. This interest was explored further in the school workshop.

Figure 5: Curiosity about IoT technology when prompted

The school workshop showed that children who commonly played with IoT toys were not aware of how the technology worked. However, they were quick to learn when shown the RFID components in the portal and the toys (Figure 6). Being able to see the technology separated from the toys allowed them to explore other ways to connect objects. After a 90-minute session, children were encouraged to design their own IoT applications. Designs included using the tags to help police locate criminals to helping farmers know when their cows had eaten (Figure 7).

Figure 6: Exploring the computing components inside Skylanders toys and base

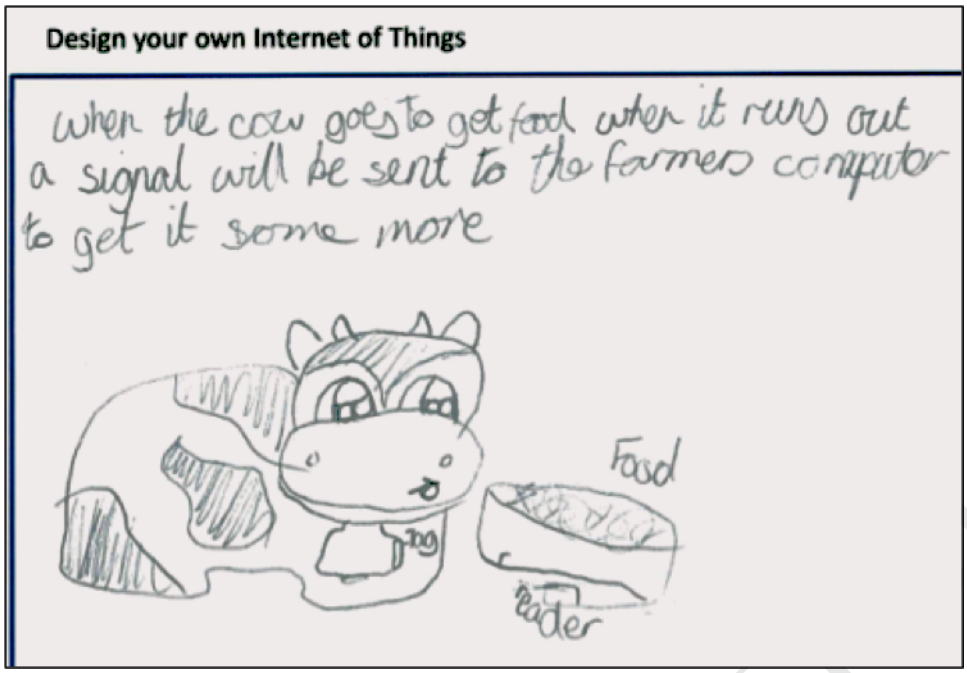

Figure 7: School workshop – child design for IoT: "When the cow goes to get food when it runs out a signal will be sent to the farmers computer to get it some more."

5. Discussion

This paper raised three questions about the IoT and children and explored these questions in the context of a recent IoT technology being used in homes. Whilst the toys offer a relatively constrained form of digital interaction (just responding to being placed on a base), they provide a window into this emerging technology.

5.1 How do IoT devices influence children's interpretation of, and interaction with, everyday things?

The IoT has the potential to change how children perceive and interact with everyday things. In this study, physical toys were predominantly perceived and used as accessories to video games, although there were instances, particularly for young children, of playing with the toys independently of video games. What was not observed, but seems to have much design potential, is the ability to develop children's perceptions of physical things based on their linked digital experiences. This is likely due to the nature of digital interaction offered by the IoT video games. Toys acted as tokens for virtual characters; the video games did not respond to children's actions with the toys beyond purposefully placing them on a portal. Other devices, such as *Teddy the Guardian*, illustrate the potential to capture physical interaction much more seamlessly and ubiquitously.

The perceived value of the toys seemed to restrict interaction. Children tended to parade rather than play with the toys, possibly influenced by their parents' perceptions. The younger children played with the figures away from the portal, but this was limited and, as stated, the technology cannot detect, capture or respond to this form of play. This can be contrasted to some tangible game designs such as Knight's Augmented Castle[4], a prototype in which RFID is integrated into a physical castle playset to enable children to explore digital effects together in a physical environment.

By capturing a wider range of children's collaborative interactions, future IoT designs have greater potential to influence children's physical and social play. Unhindered by the location of portals, or parental rules, there is much more potential to design toys that are sensitive to how they are moved around children's environments. With this design potential, however, it remains important to question how children's personal, social and environmental interaction is being shaped by the technology.

[4] http://www.vs.inf.ethz.ch/res/show.html?what=akc

5.2 How is the data that is captured by the IoT video games being used?
Data for children's physical activity captured by the IoT video games is relatively limited yet still reveals which toys are most commonly used, whether this is alone or with other toys, and when. For instance, the device could detect when a new character is introduced. Combined with a registration process which requests the child's date of birth it would be possible to infer that the toy had been bought as a birthday present, leading to on-screen suggestions for further purchases.

While some of this data might be generated by a video game without toys, IoT-object data tracks children's physical interactions. It is not difficult to conceive of toys capturing data beyond simple placement on a base: by including data on their location, or how they are moved in relation to other toys. The more IoT objects are able to capture children's interactions with everyday things, the more they are able to build a comprehensive picture of children's day-to-day lives. The point here is that the IoT has the potential to generate powerful data about children's lives, in a way that has some similarities with the ways in which companies capture data about adults' lives from their online interactions. There is a need, then, to monitor what data is being captured on children's activity, and how this is being used.

5.3 How cognisant are children, and their carers, of IoT designs?
The research suggests that this new form of technology has entered many homes by stealth as parents and children were not really aware of how the technology captured children's interactions. The school workshop showed that this could be easily addressed, and indeed greater knowledge of this emerging technology would align well with the recent drive to extend computing education (Manches, 2014). Nevertheless, even if children understand the technology, the way IoT can digitise interaction with everyday things will make it more seamless and therefore less visible. As environments become increasingly interconnected, capturing more and more data on everyday interaction, it is important that all of us are more mindful of this digitisation of the physical world.

6. Acknowledgements
As well as participating families, we would like to thank project members: Chris Speed, Eric Laurier and Stephanie O'Donohoe at the University of Edinburgh. *Children and the Internet of Things* was funded by the Challenge Investment Fund of the College of Humanities and Social Science, University of Edinburgh.

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