The Use of Interactive Toys in Children's Pretend Play: An Experience Prototyping Approach

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Abstract

Background Interactive technology can greatly enhance several behavioral and cognitive aspects of children's play. However, little is known about the manner in which children accept and use technology in toy-based play. Therefore, in this study, we adopted the experience prototyping approach to examine how children and parents utilize digitally enhanced toys, especially in pretend play that entails symbolic and social behaviors.

Methods We used several types of experience prototypes that could augment traditional non-digital toys in an interactive manner. A user study was conducted using a sample of eight parent-child dyads. Their play behaviors using the provided experience prototypes were observed. Additionally, a post-play semi-structured interview was conducted to further explore the thoughts and intentions that underlay play behaviors.

Results The results revealed that children used the predetermined and open-ended symbolic stimuli of the experience prototypes to create symbolic pretenses. Digitally enhanced toys helped children exhibit imitative actions and constructive behaviors. We also identified the opportunities and challenges that children encounter when interactive systems are used in social pretend play. With respect to input methods, participants preferred the system with a simple way of manipulation.

Conclusions Overall, children and parents expressed their needs, preferences, expectations, and frustrations regarding the use of interactive technology in symbolic and social pretend play. The findings and implications of this study can be informative to toy designers and researchers who are interested in developing interactive tools or systems for children.

Keywords Interactive Toys, Children, Interactive Play, Pretend Play, Experience Prototyping

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1. Introduction

Developmental theorists have proposed that positive affect, non-literality, intrinsic motivation, process orientation, and free choice are the key features of children's play (Garvey, 1977; Rubin, Fein, & Vandenberg, 1983). Non-literality refers to children's preference for inner rather than outer reality; this is especially apparent in pretend play. A child who is engaged in pretend play conflates a make-believe state with reality, and consequently dismisses the constraints of reality and replaces the actual meanings of things, actions, and circumstances with their own subjective meanings (e.g., a child may pretend that a banana is a telephone). Pretend play gradually evolves in such a manner that the child is eventually able to carry out a long, integrated, and a planned sequence of pretenses, most of which occur in social contexts (Fenson & Ramsay, 1980). Symbolic and social pretenses enable children to develop physical, cognitive, and social abilities by helping them understand the properties of reality, relationship between things, and roles of other people.

Children's imaginations are not always unobservable; a child may express his or her imagination by utilizing a toy as a pivot to switch between covert imagination and the real world. The recent emergence of digital technology offers new opportunities for interactive toys and digital play to enrich children's entertainment and education (Plowman & Stephen, 2005; Radu & MacIntyre, 2012; Yilmaz, 2016). Smart toys, interactive toys, and augmented toys have been defined as playthings that use the power of a computer to incorporate sophisticated sensors and electrical circuits and in turn enrich play experience (Allen, 2004). Regarding pretend play with symbolic and social behaviors, these toys are equipped to respond to children's manipulations (e.g., speech, movement) and provide children with a more vivid experience of their symbolic thoughts during pretend play. In the field of human-computer interaction (HCI), interactive systems have been developed to support children's pretend play by providing virtual and tangible symbolic stimuli and facilitating digital interaction (i.e., through mobile devices, tabletop displays) even in remote conditions (Freed, 2010; Mansor, 2012; Ryokai, Raffle, & Kowalski, 2012). Further, several studies have shown that interactive technology-based play fosters social collaboration, creative storytelling, and emotional expression (Bai, Blackwell, & Coulouris, 2015; Farr, Yuill, & Hinske, 2012; Kara, Aydin, & Cagiltay, 2012). For instance, the FingAR puppet system, which utilizes a tabletop-augmented mirror system and an augmented reality (AR) technology, affects the complex cognitive skills that are involved in pretend play. This system helps children understand and verbally express their emotions during social play. In the marketplace, The Moff Band (Moff, 2014) and Parker the Bear (Seedling, 2017) are outstanding merchandise that allow children to engage in pretend play by producing a variety of sounds from their own bodily movements and looking at a visually augmented toy as if they are being a doctor who treats a bear with illness (Figure 1).

Figure 1 The Moff Band (Left), Parker the Bear (Middle), and the FingAR puppet system (Right)

The importance of understanding how interactive toys affect children's play experiences and how they should be designed has been recognized in the fields of child psychology and child-computer interaction (CCI). Although parents and children accept and play with interactive toys, few research studies have examined how children utilize interactive technology in their play (Johnson & Christie,

2009). In particular, it is still unclear how can we create interactive toys that promote various positive user experiences in symbolic and social pretend play, such as creativity and social interaction (Levin & Rosenquest, 2001; Marsh, 2002). HCI researchers have underscored the need for studies that investigate how children's manipulation of and interaction with interactive toys influences their play and learning process (Marshall, 2007). In addition, designing interactive toys for pretend play requires further exploration that aims to integrate interactive technologies and traditional toys. The design and development of interactive toys must capitalize on experiential features that technology has to offer, while also preserving the benefits of traditional toy play (Hinske, Langheinrich, & Lampe, 2008; Marco, Cerezo, & Baldassarri, 2010).

This study was intended to serve as an important contribution to the design of prototypical toys that help children explore, discover, and use interactive technology during pretend play. Accordingly, we adopted an experience prototyping approach, which can nurture children's imagination by helping them use traditional non-digital toys in an interactive manner. Additionally, a user study was conducted with children and their parents to examine the experiential influences of interactive technology on pretend play. The findings delineate the technologies that are valued, the manner and contexts in which they are used, and the purposes for which they are used in pretend play. The results of an observational study that utilized experience prototyping was expected to reveal the influence of interactive technology on various aspects of children's pretend play, namely, the diversification of children's imaginative thoughts and the facilitation of social exchange of imaginary content. The results were to be used to propose several design implications that pertain to the use of digital technology in interactive toys and systems for pretend play.

2. Methods

2. 1. Experience Prototyping

We used the methodological approach of experience prototyping to explore how interactive technology, which entails an integration of digital advancements and traditional toys, influences children's representations of objects and symbols, and play. Buchenau and Suri (2000) were the first to suggest that an experience prototype is "any kind of representation, in any medium, that is designed to understand, explore or communicate what it might be like to engage with the product, space or system we are designing." Experience prototyping is an advantageous methodological instrument because it helps us understand existing experiences and explore the design space of new technology. Researchers can use experience prototyping to understand user interaction with the system in physical, narrative, and interactive contexts; it also allows a researcher to be inspired and confirm or reject ideas based on the quality of experience that the prototype engenders.

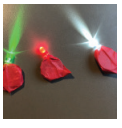
2. 2. Experience Prototypes

We developed four types of experience prototypes (Figure 2). In order to augment interactive technology, we considered the many different means by which prototypes can be attached to objects by having adhesiveness, augment virtual images, or be separated from objects. It was also designed to provide audiovisual stimulation through various channels and explore how children incorporate multisensory stimulation. Further, a variety of input methods (e.g., buttons, touchscreens) were used to explore usability challenges and the level of functional complexity that is appropriate for the use of interactive technology in children's play. With regard to the symbolic stimuli that pretend play entails, we employed predetermined and open-ended means of augmentation; this was intended to clarify whether children's pretense was founded on symbolic stimuli or their own subjective interpretations of stimuli. Also, we considered different levels of authoring by which children can personalize symbolic stimuli in desired ways. Four experience prototypes that integrated digital augmentation and tangible toys were used: (1) a drawing application that was installed on a tablet device was used with a connected projector; (2) the Moff Band and an adhesive gel pad; (3) a voice recorder with an adhesive gel pad; and (4) LEDs with coin cells (Table 1).

Figure 2 Types (Left), adhesiveness of the experience prototypes (Middle), and user-study experimental setting (Right)

For the first experience prototype, we installed the children's drawing application on the Microsoft New Surface Pro. The drawing application afforded a straightforward interface that children can easily select colors, draw lines, and erase drawings with fingers. The projector was connected to the tablet device using an HDMI cable, which was fixed to the arm of the adjustable pole system, AutoPole, and it projected children's drawings. The Moff Band is a type of wearable bracelet that sonifies user gestures; we modified it in such a manner that it could be easily affixed to objects. A 2 mm 3D printed frame was used to attach the board to both sides of the adhesive gel pad of the Moff Band. The Moff application was paired with an iPhone 8 to produce a variety of auditory feedback related to everyday sounds, such as motorcycle, animal, fireworks, baseball, etc. Similarly, the recorder prototype used a conventional recorder module and was incorporated into the gel pad using a 3D printed frame. When it was pressed continuously, a beep was emitted to indicate that the recording had commenced; the recorded sound was produced when it was pressed briefly. For the last experience prototype, red, blue, yellow, and white LEDs were connected to a circuit-free coin cell to ensure safety. The LEDs were provided with its lights on, without requiring any additional manipulation of children.

Table 1 The characteristics of the developed experience prototypes

Experience Prototype	Level of Authoring	Symbolic Stimuli	Sensory Stimulation	Input Method	Adhesiveness	Functional Complexity
Drawing application installed on a tablet device and connected to a projector 	High	Open-ended	Visual	Touch	X	High
The Moff Band and an adhesive gel pad 	Low	Predetermined	Auditory	Gesture	O	High
Voice recorder with an adhesive gel pad 	High	Open-ended	Auditory	Button	O	Middle
LEDs with coin cells 	Low	Open-ended	Visual	-	X	Low

2. 3. User Study

2. 3. 1. Participants

The study sample included parents and children because children may find it difficult to create interactive solutions using unfamiliar technology; therefore, parents were expected to complement their children's lack of experience with new technology (Kafai, 1999). We focused on children between the ages of 3 and 7 years; by this age, children engage in deep and detailed symbolic thoughts as well as understand and utilize interactive technology. Eight parent-child (i.e., two boys and six girls) dyads were recruited via an email list of parents who reside around Daejeon, South Korea (Table 2; labels for children = C1–C8; labels for parents = P1–P8, mean age of the children = 3.88, SD = 1.13). All participants had a South Korean cultural background. The participated parents had well-educated backgrounds (i.e. having at least a bachelor's degree) and were highly interested in caring and educating their children. Two groups of two dyads (Group C and F) were required to participate as a single group so that the children's social play could be observed.

Table 2 A profile of the user study participants

Group	Participant Code	Age	Gender	Favorite Toy and Play Theme	Familiarity with Technology (5-point Likert Scale; 1-Not familiar; 5-Very familiar)
Group A	C1	6	Female	Kick scooter, Sound book	3 / 5
	P1	34	Female	–	–
Group B	C2	5	Female	LEGO block, Kitchen play	2 / 5
	P2	34	Female	–	–
Group C	C3	4	Female	Clay, Drawing using mobile devices, Watching YouTube, Hospital play	5 / 5
	P3	33	Female	–	–
	C4	3	Female	Clay, Sticker	2 / 5
	P4	33	Male	–	–
Group D	C5	4	Male	Car toy	3 / 5
	P5	36	Male	–	–
Group E	C6	3	Female	Bicycle, Car toy	3 / 5
	P6	38	Male	–	–
Group F	C7	3	Male	Car toy, Dinosaur toy	5 / 5
	P7	31	Female	–	–
	C8	3	Female	Sound pen	2 / 5
	P8	42	Male	–	–

2. 3. 2. Setting

The study was conducted in a laboratory that was redesigned to appear as a play space. Experimental settings can alter the behaviors that are otherwise observable in one's natural habitat; however, it allows the researcher to focus on a given participant and collect rich data from even small samples. Further, some experience prototypes can be too large to be installed; therefore, it may be difficult to use them at home or on the playground. We designed the experimental environment according to Read's (2015) guidelines on researching children. The study was conducted in a 3.6 m × 3.6 m indoor space; play mats were used to ensure the safety of children. Open spaces on both sides of the window were provided to ensure that children do not feel trapped within the laboratory. Camera settings and locations were explained to the participants, and written and verbal permissions were obtained from both parents and children. The entire study was video-recorded; the camera was positioned at one corner of the room and faced the entire matted space.

2. 3. 3. Procedure

The user study consisted of two observational sessions and a post-session interview. After the objective and procedure of the study were briefly introduced to the participants, they responded to a questionnaire that required the following information: personal information, their child's favorite toy, and their child's familarity with a digitally enabled toy. Once the participants were briefed, they responded to a consent form; they could withdraw from the experiment at any point during the study.

During the first 15 minutes, children were allowed to play freely with non-digital traditional toys; this was done to help them feel comfortable in a relatively unfamiliar experimental environment. They were presented with a wide range of traditional toys (e.g., blocks that can be used to build structures, dolls whose physical forms could be linked to specific symbols) to ensure that they engaged in a wide range of play behaviors. We also provided them with materials such as paper, colored pencils, and tapes to facilitate the expression of constructive behaviors. Children were also allowed to bring and play with their favorite toys.

The second session, during which the experience prototypes were used, lasted for 15 minutes. The study instructor informed the children and parents that they could play with the prototypes along with the traditional toys. However, the instructor provided neither additional guidance about the application of the experience prototype (i.e., beyond those that pertain to its basic functions) nor explicit prompts to use it as a part of their play. Since play is an activity that freely occurs and cannot be enforced or limited, we limited our interference to the provision of the prototypes, passive observation, and video recording. However, parents were expected to guide and support their children's use of and play with the unfamiliar prototype.

In the post-session interview, the instructor questioned the children and parents about the following: an explanation of their play during the session, perceived differences in the play experience (e.g., communication, recognition of objects, enjoyment) with and without digital technology, the utilization and characteristics of each experience prototype, feedback about the stimuli and the study setting, and the possibility of future use of interactive technology in children's play.

3. Result

The qualitative data that were obtained from the user study were subjected to content analysis, whereby they were coded and categorized. Firstly, transcriptions of the recorded play behaviors and post-session interviews were transcribed sentence by sentence and tagged with representative keywords also. The keywords were utilized to efficiently handle a large quantity of qualitative data and construct the first version of a coding scheme. Then, we coded the transcriptions focusing on pretend-play events and clustered the derived codes into large categories. The researcher who coded the data has more than five years of experience in interaction design and is skilled in qualitative content analysis. The coder conducted the analysis three times, with a time span of two weeks between each coding session. As coding proceeded, the initial version of the coding scheme was supplemented by combining and eliminating some codes.

Subsequently, 154 verbal and behavioral events were clustered into the following thirteen codes: exploration of technology (5), pretense involving the object (19), pretense involving the body and space (5), expression through imitative action and constructive behavior (20), support of diverse play themes (18), role distribution and rulemaking (11), compliments and encouragement from parents (18), annoyance in response to interference from others (3), attraction toward technology (4), difficulty in manipulation (13), request to solve difficulties (4), learning to manipulate (4), preference for simple manipulation techniques (3), and other thoughts and behaviors (27; Table 3). Similar codes were also clustered across the following three categories: symbolic behavior, social behavior, and functional manipulation.

Table 3 The emergent content categories and codes

Category	Code	Number of verbal and behavioral events
Symbolic behavior	Exploration of technology	5
	Pretense involving the object	19
	Pretense involving the body and space	5
	Expression through imitative action and constructive behavior	20
	Support of diverse play themes	18
Social behavior	Role distribution and rulemaking	11
	Compliments and encouragement from parents	18
	Annoyance in response to interference from others	3
	Attraction toward technology	4
Functional manipulation	Difficulty in manipulation	13
	Request to solving difficulties	4
	Learning to manipulate	4
	Preference for simple manipulation techniques	3
Others	Other thoughts and behaviors	27

3. 1. Utilizing technology to diversify pretense involving the object

The child participants were interested in the multi-sensory stimulation that the experience prototypes provided, and they used it to assign symbolic meanings to the toys. For example, when C1 heard the sound of a magic wand from the Moff Band, which was attached to a wooden brick, she symbolized the brick as a magic wand and narrated a story in which she turned her mother into a frog by casting a magic spell. Some participants not only adopted the stimuli that they were provided but also interpreted interactive technology in a subjective manner. This was possible because several experience prototypes were embedded with open-ended and undetermined symbolic meanings that were subject to interpretation. For example, C6 symbolized LEDs lights as the light of a train on which she rode or the candles that she had blown at her birthday party. Through building diverse symbolic pretenses, children exhibited play themes related to pretenses such as alien play, animal play, fishing play, kitchen play, house-building play, hospital play, police play, car play, and dinosaur play.

Parents positively appraised the capability of digital technology in meeting the diverse interests of children, thereby offering parents a convenient strategy that circumvents their worries about providing playthings to their children. We found that children's interest in toys changed constantly, and it was hard to anticipate the course of their play. P2 noted, "Children are never bound to a single toy. They always want to explore new playthings though they already have enough toys. All parents have to buy a ton of toys and honestly this brought a financial burden for me." Digital technology is more likely to interest children than traditional toys. P3 observed, "Typical toys support children to practice specific play. But, these (prototypes) can widen the usage of a limited number of toys for diverse play."

Figure 3 Exploration of the Moff Band's predetermined stimuli (Left) and actions that express symbolic thoughts (Right)

3. 2. Building pretense based on both symbolic stimulus and appearance

The user study found that children build pretense on an object while considering both the physical appearance of the object and symbolic stimuli of the experience prototypes. When predetermined or open-ended symbolic stimuli evoked imaginative symbols, children showed to utilize objects having the physical appearance that can accompany the symbols. The symbolism and designated roles of most toys are hard to change; however, bars that have an abstract shape can be remodeled into other things (e.g., knife, magic wand, pillar, train) depending on the symbolic stimulation. For example, when C5 and P5 were playing with the Moff Band prototype, which was attached to a wooden stick, C5 said, “Look, this (wooden stick) can be a frying pan. (After change symbolic stimuli to a hammering sound) And now this is a hammer.”

As such, physical appearance is a significant design factor as digital stimuli when developing an interactive toy system. Across both sessions (i.e., with and without experience prototype), children's symbolic pretense was classified into three categories, based on the external characteristics of the physical object, namely, role pretense, tool pretense, and space pretense (Table 4). We defined objects that are physical references for each classified pretense type such as a role toy, tool toy, and space toy. Accordingly, role toys are objects that have a specific role in pretend play (e.g., puppy, baby). Tool toys are used to perform the imitative actions that are associated with symbolic pretenses; stick- and rod-shaped objects belong to this category (e.g., knife, fishing rod, spoon). Space toys spatially contain other toys; therefore, the toy can be used as a house or a fish tank.

Table 4 Three categories of symbolic pretense that emerged in the user study

Category of symbolic Pretense	Form	Symbol
Role pretense		Man, Puppy, Tiger, Bear, Family member, Baby, and Ghost
Tool pretense		Knife, Pickax, Fishing rod, Cooking utensil, Spoon, Hammer, Candy bar, and Dental tool
Space pretense		Bathtub, House, Fish tank, School, Plate, and Building

3. 3. Exhibiting imitative and constructive behaviors

Children actively exhibited imitative behaviors in their symbolic pretend play with toys. Similar to play with traditional toys, imitative behaviors appeared when children were deeply immersed in pretend play or augmenting themselves as if having roles. For example, C5 pretended to catch a fish by using the Moff Band prototype-attached block as a fish rod and turning the insubstantial handle of the rod. It was particularly common for children to use the Moff Band to exhibit imitative behaviors because the prototype provided auditory feedback in response to the gestural input. Thus, the gestural input method could lead children to perform bodily actions and relate these actions with imitative behaviors of imaginative roles.

Also, children demonstrated constructive behaviors by creating toys using materials and other toys. For example, C5 created a train by arranging LEDs and round materials on a long square acrylic plate and said, “I will pretend that this train has different colors in each portion.”This example demonstrates that

children use the characteristics of interactive stimuli to actualize their own toys and engage in make-believe play that entails desired symbolic thoughts.

3. 4. Having two sides while utilizing technology in social interaction

Digital technology positively and negatively influenced social pretend play. In social-play environments, shared audiovisual feedback helped gain other children's attention and facilitated mutual pretend play. For example, C8 was interested in an animal sound that C7 generated while using the experience prototype; subsequently, C8 asked C7, "What is this sound about?" Since the auditory feedback was omnidirectional, it piqued the curiosity of children who were playing independently.

However, there were some concerns that interactive technology could interfere with social play. In particular, excessive engagement with digital technology hindered social interaction. Attention towards touch manipulation and subsequent screen changes detracted children from social play. For example, C7 ignored his mother's encouragement to engage in social play and focused on the screen changes that his touch manipulation yielded. There were conflicts amongst children who tried to simultaneously operate a single device (Figure 4: Right). For example, C3 and C4 cooperatively drew an animated character using the drawing application; however, one of them was annoyed when it was distorted by the manipulation of the other.

3. 5. Parental role as a supportive assistant in social pretend play

Parents played an important role in children's acceptance and utilization of digital technology in a social context. They encouraged their children to explore the experience prototypes and asked them how they would like to utilize digital technology in their play. For example, P2 complimented C2's use of the voice recorder: "Great job. This is the sound you are producing."

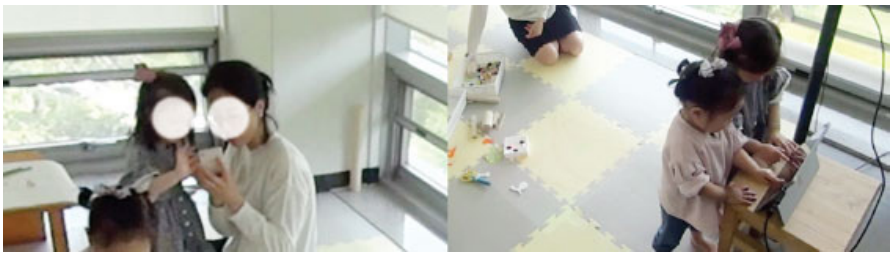


Figure 4 Manipulation of the prototype (Left) and simultaneous social conflict and control of the prototype (Right)

P5 described his role in social play with C5 as that of "a supportive assistant." Parents, who became aware of their child's symbolic use of digital technology, were eager to engage in social play through role distribution and rule organization. For instance, when C5 pretended that the Moff Band prototype-attached block was a fish rod, P5 suggested that C5 was a fisherman and that he was a chef: "Oh, you are a fisherman. I will cook food if you catch a fish. Please catch some fish for me... I am waiting now." Thus, parents helped their children express their symbolic thoughts and deeply immerse in pretend play. Moreover, they also helped their children recall memories and build mutual pretenses by asking questions and seeking explanations. For example, parents helped their children utilize symbolic stimuli to recall previous experiences of fishing in a river (C3, P3), travelling in a train with one's grandmother (C4, P4), and blowing a candle on one's birthday (C6, P6).

3. 6. Preferring easy and direct ways of functional manipulation

Although adults may find the developed experience prototypes to be user-friendly, children were found to experience several unexpected challenges. For example, they found it difficult to operate a voice recorder that functions differently depending on how long a button is pressed, and a tablet device that entails

complex operational steps. Similarly, with regard to the gestural inputs that the Moff Band requires, not all symbolic pretenses could be accompanied by a shaking motion; thus, interactive toys should not solely rely on uniform gestural inputs (P7). Although admitting the benefit of gestural input in eliciting imitative behavior, parents suggested that the one-button manipulation is appropriate for use with children; familiar button control in interactive toys provides immediate audio or visual feedback. Also, when the input and output devices were separated (e.g., the tablet device and projector, the Moff Band and cell phone) children were confused about creating symbolic pretenses. For example, children easily drew with their fingers on the tablet device; however, they could not use these authoring activities to augment and symbolize physical toys.

4. Design Implications of Future Interactive Toys for Pretend Play

The results from the user study led us to come up with several implications that can be informative to toy designers and researchers for children's pretend play. Mainly, we derived four design implications regarding abstract physical appearance of toys, gestural input method, authoring feature of symbolic stimuli, and access control of shared resources.

Figure 5 Implications of toys with abstract physical appearance (Left) and wearable device using gestural input method (Right)

4. 1. Design physical appearance with abstractness that can accompany diverse symbolic stimuli

As much as digital symbolic stimuli, the physical appearance of the object is a significant; children opt to build pretense on the object that can properly accompany the provided stimuli. In particular, it was found that objects (e.g., bars and blocks that had abstract shapes) were assigned various symbols that were evoked by the symbolic stimuli and consequently this could contribute to diversify children's pretense and play theme. Based on our classification of children's symbolic pretense into three categories (i.e. role pretense, tool pretense, and space pretense), implication may employ a set of toys with abstract physical appearance in the different categories that can accompany different symbolic pretense on each toy. Abstract-shaped toys with ambiguousness are expected to be versatile as digital stimuli and more opened to interpretation for imagination, contrary to most existing toys with fixed representation and definite symbolic meaning (Figure 5: Left). Consistent with previous notions on children's interaction in creative play (Kara, Aydin, & Cagiltay, 2014; Price & Rogers, 2004), this approach can encourage children to engage in creative exploration by differentially combining physical toys, digital stimuli, actions, and interactions.

4. 2. Design to encourage children to be physically and socially active using gestural input method

The techniques for simple manipulation with immediate feedback were preferred by children and parents. Although other input methods are more complex than the one-button method, they are worth exploring because they have distinct opportunities in children's pretend play. We found that gestural inputs help children explicitly express their symbolic thoughts through whole-body imitative actions and lead to social play by assigning imaginative roles. The study led us to expect that the design of interactive toy in form of wearable device (e.g. an interactive bracelet) would afford children's natural body movement as gestural inputs and augment them as if being imaginative characters or things related to symbolic stimuli. As some parents noted that not all symbolic pretenses can be accompanied by a mere shaking motion, the design of gestural input method must rely on the distinct motion of each symbolic stimulus (e.g. a sword associates with a swinging motion and a frying pan fits to a shaking motion; Figure 5: Right). This implication may be especially beneficial for parents and educators who are eager to be a supportive assistant to induce sedentary children being more physically and socially active.

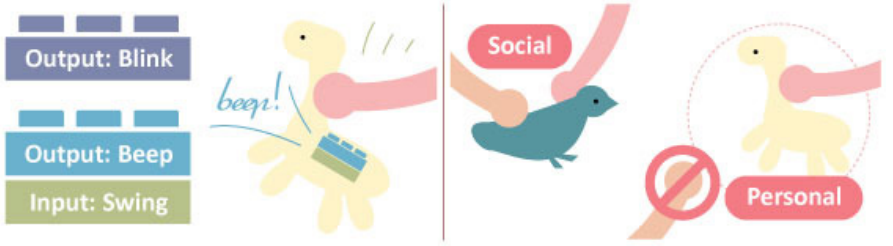


Figure 6 Implications of authoring features using tangible construction (Left) and flexible access control (Right)

4. 3. Design authoring features of symbolic stimuli as children's constructive behavior using tangible materials

The possibility of authoring can help children personalize symbolic stimuli; however, digital authoring can be unfamiliar and children could confront difficulty (e.g. drawing visual stimuli and recording own voice as auditory stimuli) to augment and symbolize toys. Thus, to support authoring of digital stimuli, design features should refer to children's personalization in physical construction using toys and play materials, which is familiar and straightforward. As children build a castle using Lego blocks, implication may afford children to put together desired interactive components and construct interactive toys in their own ways (Figure 6: Left). This block-based interaction in line with constructivism has been attempted in educative applications targeting for children (e.g. coding or storytelling), but is rarely explored in interactive toys as the way to afford children authoring of symbolic stimuli.

4. 4. Design for social play considering flexible and respectful access control of shared resources

The user study uncovered two sides of interactive technology: the one that fosters and one that hinders social interaction. Interactive toys and systems for social play can lead to excessive and competitive participation of children which can engender the social conflicts on shared resources (e.g. both tangible resources and digital symbolic stimuli). Therefore, future implication can be addressed by using subtle means of access control of shared resources and collaborative interfaces that require consensus about symbolic stimuli, as in the precedent study on collaborative working of children (Marshall, Fleck, Harris, Rick, Hornecker, Rogers, Yuill, & Dalton, 2009). For example, while some toys and digital stimuli are provided as social resources, others can identify user and only allow personal manipulation of each child (Figure 6: Right). Children can modify a range of the access when they show to reach an agreement on the resources whether to be personal or social (e.g. pushing a button at the same time or giving a voice command together). This access control strategy can assure adequate personal resources that can help

children transition from solitary to collaborative play (Rosales, Sayago, & Blat, 2015); thus, they can have enough chance to socially negotiate and make consensus to proceed pretend play in collaborative manner.

5. Conclusion

This study examined children and parents' use of interactive toys in pretend play, whereby they were required to create symbolic pretenses and share social pretenses with one another. We developed four types of original experience prototypes that differed in authoring functionality, sensory stimulation, symbolic stimuli, input method, and functional complexity. The use of interactive technology induced changes in symbolic and social behavior, and functional manipulation. These findings were used to provide design- and deployment-related considerations and implications. Thus, the study findings make the following contributions: (1) help understand the use of interactive toys in children's pretend play, (2) validate the use of the experience prototyping approach in understanding and designing interactive toys, and (3) provide implications that can be useful to design future interactive toys for pretend play.

The study findings can help interactive toy-design researchers and practitioners predict the effect of interactive technology on children's pretend play experiences, which has been unclear and controversial, and apply it in the iterative design process. The findings also serve as a worthy resource that can inform future interactive toy designers about the appropriate means and possible implications of integrating interactive technology and physical toys. In this manner, children can use the experiential opportunities that interactive technology engenders to engage in meaningful pretend play. Educators and parents can help children use technology in positive ways and consequently promote the developmental benefits that interactive toys foster. Future in-depth user studies must use larger samples so that the influence of interactive technology can be quantitatively and qualitatively analyzed. Further, children's independent social pretend play (i.e., without the guidance of parents and teachers) must be investigated to examine if the proposed design implications are appropriate for use with children.

References

1. Allen, M. (2004). Tangible interfaces in smart toys. *Toys, games, and media*, 179–194. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
2. Bai, Z., Blackwell, A. F., & Coulouris, G. (2015). Exploring expressive augmented reality: The FingAR puppet system for social pretend play. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (pp. 1035–1044). ACM.
3. Buchenau, M., & Suri, J. F. (2000). Experience prototyping. In *Proceedings of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques* (pp. 424–433). ACM.
4. Farr, W., Yuill, N., & Hinske, S. (2012). An augmented toy and social interaction in children with autism. *International Journal of Arts and Technology, 5*(2–4), 104–125.
5. Fenson, L., & Ramsay, D. S. (1980). Decentration and integration of the child's play in the second year. *Child Development*, 171–178.
6. Freed, N. (2010, January). Toys keeping in touch: technologies for distance play. In *Proceedings of the fourth international conference on Tangible, embedded, and embodied interaction* (pp. 315–316). ACM.
7. Garvey, C. (1977). *Play*. Cambridge, MA: Harvard University Press.
8. Hinske, S., Langheinrich, M., & Lampe, M. (2008, February). Towards guidelines for designing augmented toy environments. In *Proceedings of the 7th ACM conference on Designing interactive systems* (pp. 78–87). ACM.
9. Johnson, J. E., & Christie, J. F. (2009). Play and digital media, computers in the schools: interdisciplinary journal of practice. *Theory, and Applied Research, 26*(4), 284–289.

10. Kafai, Y. (1999). Children as Designers, Testers, and Evaluators of Educational Software. *The Design of Children's Technology*, 123–146. SF: Morgan Kaufmann Publishers.
11. Kara, N., Aydin, C. C., & Cagiltay, K. (2012). User study of a new smart toy for children's storytelling. *Interactive Learning Environments, 22*(5), 551–563.
12. Kara, N., Aydin, C. C., & Cagiltay, K. (2014). Design and development of a smart storytelling toy. *Interactive Learning Environments, 22*(3), 288–297.
13. Levin, D.E. & Rosenquest, B. (2001). The Increasing Role of Electronic Toys in the Lives of Infants and Toddlers: should we be concerned?. *Contemporary Issues in Early Childhood, 2*, 242–247.
14. Mansor, E. I. (2012, November). Evaluation of preschool children's fantasy play in the tabletop environment. In *Proceedings of the 24th Australian Computer-Human Interaction Conference* (pp. 361–370). ACM.
15. Marco, J., Cerezo, E., & Baldassarri, S. (2010, June). Playing with toys on a tabletop active surface. In *Proceedings of the 9th international conference on interaction design and children* (pp. 296–299). ACM.
16. Marsh, J. (2002). Electronic Toys: Why Should We Be Concerned? A Response to Levin & Rosenquest (2001). *Contemporary Issues in Early Childhood, 3*(1), 132–138.
17. Marco, J., Cerezo, E., & Baldassarri, S. (2010, June). Playing with toys on a tabletop active surface. In *Proceedings of the 9th international conference on interaction design and children* (pp. 296–299). ACM.
18. Marshall, P., Fleck, R., Harris, A., Rick, J., Hornecker, E., Rogers, Y., ... & Dalton, N. S. (2009, April). Fighting for control: children's embodied interactions when using physical and digital representations. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 2149–2152). ACM.
19. Moff. Inc. (2014). Moff, the smart wearable toy. Retrieved June, 2019, from http://www.moff.mobi/#top
20. Plowman, L., & Stephen, C. (2005). Children, play, and computers in pre-school education. *British Journal of Educational Technology, 36*(2), 145–157.
21. Price, S., & Rogers, Y. (2004). Let's get physical: The learning benefits of interacting in digitally augmented physical spaces. *Computers & Education, 43*(1–2), 137–151.
22. Radu, I., & MacIntyre, B. (2012, November). Using children's developmental psychology to guide augmented-reality design and usability. In *2012 IEEE international symposium on mixed and augmented reality (ISMAR)* (pp. 227–236). IEEE.
23. Read, J. C. (2015, September). Working with Child Participants in Interaction Design. In *IFIP Conference on Human-Computer Interaction* (pp. 655–656). Springer, Cham.
24. Rosales, A., Sayago, S., & Blat, J. (2015). Beeping socks and chirping arm bands: wearables that foster free play. Computer, 48(6), 41–48.
25. Rubin, K. H., Fein, G. G., & Vandenberg, B. (1983). Play. In E. Hetherington (Ed.) & P. Mussen (Series Ed.), *Handbook of child psychology, 4*, 693–774. NY: Wiley.
26. Ryokai, K., Raffle, H., & Kowalski, R. (2012, June). StoryFaces: pretend-play with ebooks to support social-emotional storytelling. In *Proceedings of the 11th International Conference on Interaction Design and Children* (pp. 125–133). ACM.
27. Seedling. (2017). *Parker: Your Augmented Reality Bear*. Retrieved June, 2019, from https://www.seedling.com
28. Yilmaz, R. M. (2016). Educational magic toys developed with augmented reality technology for early childhood education. *Computers in Human Behavior, 54*, 240–248.