TimeBlocks: "Mom, can I have another block of time?"

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ABSTRACT
Time is a difficult concept for parents to communicate with young children. We developed TimeBlocks, a novel tangible, playful object to facilitate communication about concepts of time with young children. TimeBlocks consists of a set of cubic blocks that function as a physical progress bar. Parents and children can physically manipulate the blocks to represent the concept of time. We evaluated TimeBlocks through a field study in which six families tried TimeBlocks for four days at their homes. The results indicate that TimeBlocks played a useful role in facilitating the often challenging task of time-related communication between parents and children. We also report on a range of observed insightful novel uses of TimeBlocks in our study.

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Design, Human Factors

INTRODUCTION
Infants start life with an extremely unique sense of time. Night is day and everything is *now*. Toddlers are introduced to the word "time" as not simply for telling time but for representing intervals and boundaries of time – dinner time, bed time, or time-out. However, in the busy world that most families live in, one of the most important lessons that a child has to learn is not *how to tell time*, but *how to understand the concept and appreciate the importance of time*. This issue arises most often through negotiations between children and parents about actives and transitions between them. For example, a parent may want to meet a goal of bringing their child to bed by a certain time while striking a balance between allowing their child time to play (20 minutes) as well as to cleanup (five minutes), read a book with them (ten minutes), brush their teeth, etc. Often, these transitions and concepts of time present significant struggles for parents and children. Our survey consisting of 20 parents with children from two to 10 years old revealed that they experience miscommunication with their children about the concepts of time 3.9 times a week on average. This indicates the pervasiveness of our design challenge.

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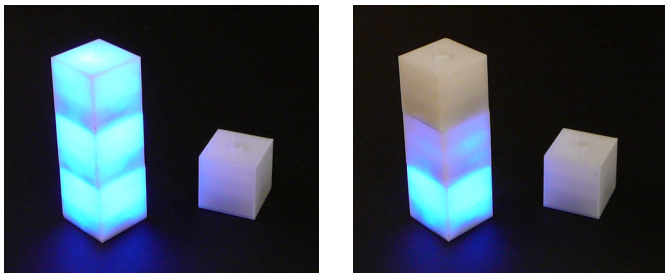


Figure 1 The TimeBlocks consist of four cubic blocks. The blocks work as a physical progress bar. Each block can represent five, ten and 15 minutes using pink, blue and green.

In this paper, we present the design, development, and evaluation of a novel tangible, playful object to facilitate collaborative negations of time between young (3-5 years-old) children and adults. Our system, called TimeBlocks (Figure 1), is not designed to be educational in terms of teaching "wall time" using a clock, but rather leverages simple playful interactions with familiar illuminated interactive blocks as a proactive tool. TimeBlocks consists of a set of cubic blocks containing full color LEDs. When activated, the blocks function as a physical progress bar that parents and children can physically manipulate. The manipulations include shaking, stacking, adding, removing and distributing the blocks. It is also possible to draw sketches on the blocks using erasable white board markers. The physical affordances (i.e., blocks) and familiar actions (i.e., shake, stack, etc.) make the interactions with TimeBlocks easy for children and adults as well as to facilitate communication about and co-creations of time concepts between parents and children.

RELATED WORK
There are many psychology works showing children gradually learn the concept of time [1,2]. Piaget found that children develop their concept of time slowly throughout their early childhood [4]. These works indicate that young children have difficulties in understanding the intangible concept of time.

To teach abstract concepts, tangible interfaces are frequently used [3,5]. For instance, MiMs is a set of building blocks that encourage children to learn abstract concepts by simulating them through physically manipulating the blocks [6]. These educational tangible interfaces work as systems separated from other physical objects in our daily life. Furthermore, they are mostly used in educational contexts (e.g., classrooms).

There are some commercial products that communicate time to children. However, unlike TimeBlocks, these products use simple "wall clock", "hourglass" or "kitchen timer" metaphors that are less interactive and not well integrated with children's playful world. While TimeBlocks was inspired by hourglasses that could be easier for children to understand owing to its spatial representation of time [4], TimeBlocks provide rich interactivity and enjoyments for both parents and children.

Through the development and the evaluation of TimeBlocks, this paper makes novel contributions. The first contribution is that TimeBlocks suggest an open tangible system where the tangible devices are used together with other objects in daily environments in many different contexts, as opposed to the closed tangible system where the tangible devices are used only as a part of specific system. The second contribution is that we demonstrated that TimeBlocks facilitate communication between parents and young children. While many existing works for young children have focused on education, only few works have investigated communication using tangible interfaces. We believe that, through these contributions, our paper can provide new insights to our community.

DESIGN PROCESS

We started from brainstorming about the design of TimeBlocks. The primary design choices were the physical shape of the blocks and the way of mapping different durations to the blocks. Through discussions among our design team, we came up with multiple possible designs (Figure 2), and built mockups using form core boards.

We interviewed four parents to evaluate these mockups. All of them had at least one 3-5 years-old child. Each interview took about 90 minutes. All parents were very positive toward our idea of using physical blocks to show time. They told us that using colors was essential to attracting children's interest, and that having too many blocks could be troublesome because they had to keep the blocks easily accessible at home to use the block on a daily basis. They also told us that their children would understand that blocks of the same size could represent different durations if the visual of the blocks (such as colors) is clearly different.

PROTOTYPE

Motivated by our interviews with parents, we designed a series of functional prototype TimeBlocks to use in series of field evaluations. We constructed four prototype TimeBlocks, each containing a small microcontroller, an

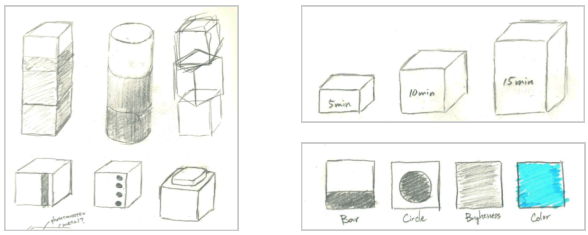


Figure 2 Early design sketches of the TimeBlocks.

accelerometer, a set of three full color LEDs, and a compact lithium ion battery. The LEDs served to communicate a progress bar metaphor. Users were able to configure each block to represent a different quantity of time (i.e. five, ten, or 15 minutes), which are represented using different colors (i.e., pink, blue and green). A fully illumined block represents the full quality of time and a darken block no time. All LEDs turn on when the timer starts, and turn off one by one after each third of the configured time has elapsed. Additionally, all LEDs fade in and out every two seconds to indicate that the timer is activated.

It is also possible to use a combined stack of blocks. For instance, if a user stacks three blocks configured as five minutes timers, they work as a 15 minutes timer. The block on top of the stack is activated first, then, after five minutes, the top block turns off and the second block becomes active. This way, TimeBlocks can represent any period from five minutes to 1 hour at the right granularity.

Hardware Architecture

The hardware architecture of TimeBlocks consists of three full color LEDs, an accelerometer, two infrared transceivers, a speaker, a battery and an Arduino Pro Mini microcontroller (Figure 3). The cubes are internally divided into three optically distinct regions. Each region contains one of the LEDs. By controlling the LEDs, the cubes can show vertical progress bar with three states. The cubes communicate with each other using the transceivers at the top and the bottom when stacked. At the center of the top face, the cubes have round projections, which fit holes at the bottom face of the cubes. These projections and holes allow even young children to easily stack and align the cubes.

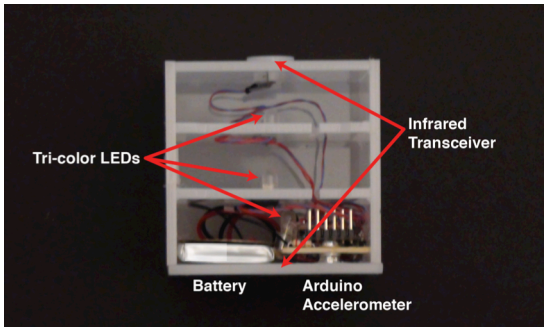


Figure 3 The implementation of the Time Blocks. The block is divided into three optically distinct regions. Each region contains one full color LED.

INTERACTING WITH TIMEBLOCKS

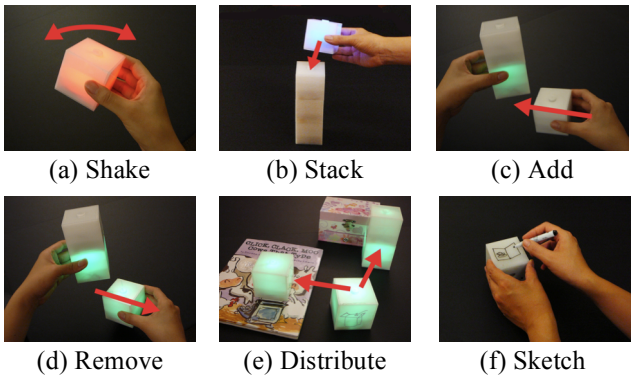
TimeBlocks utilize the physical affordance of the blocks to support many natural interactions that allow a wide range of users to manipulate duration physically (Figure 4).

Shaking: Shaking a block the first time turns on its LEDs. Further shaking causes the LED's color to cycle between pink, blue and green, which represents five, ten and 15 minutes respectively. Placing the block on a horizontal surface will starts the time countdown. Moreover, the LEDs start fading in and out every two seconds as an indication of being activated.

Stacking Blocks: In addition to configuring one block as a five, ten or 15 minutes timer, stacking the multiple blocks allows configurations of other durations. When configuring a stack of blocks, putting one activated block on the top of inactive blocks copies the configuration to the inactive blocks. For instance, stacking three inactive blocks and putting one pink (i.e., five minutes) block on the top of them turns the three inactive blocks pink, creating a 20 minutes timer.

Adding or Removing Blocks on the Fly: Adding a block to the bottom of a stack extends the timer duration. This typically happens, for instance, when children say, "I want to play more". Similarly, removing a block from the bottom shortens the timer duration.

Distributing Blocks: Once a stack of blocks is activated, the blocks count time in the stacked order even if they are distributed later. Thus, users can physically distribute the blocks to show the allocations of the timer durations. Furthermore, users can also draw on the faces using erasable markers to illustrate time allocations.



(a) Shake (b) Stack (c) Add

(d) Remove (e) Distribute (f) Sketch

Figure 4. Interacting with TimeBlocks. Utilizing its physical affordance, TimeBlocks allows intuitive and physical manipulations of time.

EVALUATION

We conducted a field study with a set of four TimeBlocks prototypes. The field study ran for four days for each family. On the first day, we brought the TimeBlocks prototypes to a participant's home where we met with parents and children together and briefly explained the method of interacting with the blocks. Although we demonstrated its usage for illustrating concepts of TimeBlocks, we did not provide specific examples for context of use to avoid biasing our participants.

After four days, we returned to the participants' home and conducted a semi-structured interview with the parents. The interview lasted approximately an hour. Although our study periods were not long enough to mitigate the novelty effect, we believe that this study provided many interesting insights about how parents and children interacted with TimeBlocks in practice.

RESULTS

We recruited 17 participants (Table 1) by posting a flyer to a mothers' mailing list in the local area. All the parents were female. Each family tested TimeBlocks for four days.

Families	Parents	Children
F1	P1 (39)	G1 (8), G2 (5)
F2	P2 (42)	B1 (10), G3 (8), B2 (6), B3 (4)
F3	P3 (46)	B4 (5)
F4	P4 (35)	G4 (5)
F5	P5 (30)	B5 (2)
F6	P6 (43)	G5 (4), G6 (8)

Table 1 Participants for the field study. P, B and G denote parent, boy and girl respectively. The numbers in the parentheses denote their ages. Each family tried TimeBlock at their home for four days.

All the parents were very positive about TimeBlocks. The parents agreed TimeBlocks helped the time related communication between them and their children (with the median of 4.5 in the 5 point Likert scale). P1 said, "In the morning, I used three ten-minute blocks and told my daughters to do teeth brushing, changing clothes and preparing things for school for each block. Then, they actually followed the sequence and finished everything in the 30 minutes without me saying it again. It was great."

For all the children older than seven years old (G1, G3, G6 and B1) and some other children (G4 and B2), the parents strongly agreed (5 in the Likert scale) that the children understood that TimeBlocks represented durations, and that different colors denoted different lengths of durations.

For two younger children (G2 and B4), both of the parents disagreed (2 in the Likert scale) that the children understand TimeBlocks represented durations. P3 said, "When my son [B4] starts playing with a toy, he really focuses on the toy, and forgets the blocks". This could imply that, rather than TimeBlocks were difficult to understand, they were not attractive enough for them to *try* to understand the concept.

For other children, parents agreed (4 in the Likert scale) that their children understood that TimeBlocks represented durations and that the different color denoted different lengths of durations. P2 reported that her son [B3] said, "I want to use a green block not a red block because I can play longer". This clearly indicates that B3 understood that a green block denotes longer time than a red block. P5 also

said, “My [two-years-old] son [B5] can’t read numbers, can’t read clocks. But he did understand the TimeBlocks”.

All parents reported that they had stacked blocks, and that they and their children enjoyed seeing the color propagating from the block at the top of the stack to the block at the bottom. P1, P2 and P4 commented that their children stacked the block by themselves. The parents observed that stacking the block gave their children the feeling that *they* made the timer, and that this made their children appreciate the blocks. P2 said, “My daughter [G3] wanted to configure 30 minutes. But, if she used five minutes blocks, she didn’t have enough number of blocks. She pondered for a while. Then, she came up with using three ten-minutes blocks or two 15-minute blocks. This made her really like the blocks”. Furthermore, all parents except one mentioned that they added blocks to extend the timer duration on the fly. They said that extending time by adding blocks was useful because it happened frequently in daily scenarios and because their children could use the blocks as a unit of time when telling their parents how much extension they wanted.

P1 and P4 said that they sketched on TimeBlocks to show time allocations. P1 and G1 created a schedule to leave home (Figure 4). P1 said, “Letting my daughter [G1] sketch things on the blocks helped us to talk about the schedule. […] Then, she actually followed the schedule.”

P1 also mentioned that she let B1 to allocate time by physically distributing the blocks. P1 said, “I gave him [B1] four 15 minutes blocks and told him that he had to study for one hour. Then, he decided by himself that he studied for these two blocks, took break for this block and studied again for this block. […] I think these blocks help him to learn how to manage his time.”

These observations indicated that TimeBlocks would facilitate time-related communications between parents and their children. Furthermore, they implied that children understood TimeBlocks and enjoyed using them.

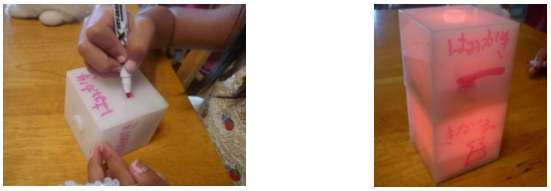


Figure 4. Eight-years-old girl was sketching on the blocks (left) to show a sequence of tasks (right). She drew the word “tooth brushing” and a brush on the top block and the word “changing clothes” and a cloth on the bottom block.

DISCUSSION

Although the primary purpose of TimeBlocks was to facilitate communications between parents and children, three of the parents in our study indicated a desire to use it for education. The most common scenario parents described was using it to teach concepts of time to younger children. Another interesting scenario suggested by our participants was that they could teach the concept of units. For instance, parents expressed interest in demonstrating how time is represented differently based on the unit of measure; e.g., observing that a stack of three pink (five minutes) blocks expires at the same time as a green (15 minutes) block.

A surprising unintended usage expressed by every parent in our study was the desire to use TimeBlocks as personal timers themselves. One of the parents told us that she wanted use the blocks when she knitted. She said, “When I knit, I just continue knitting. It’s great to have an unobtrusive timer like this”. Another parent said, “When we are preparing for school, […] I found it was very useful for me to have the timer which I can glimpse”.

Finally, our participants reported that they used TimeBlocks in a variety of locations around the home, including bathrooms, bedrooms, living rooms and kids’ rooms. This indicates that the design of TimeBlocks, which does not require any external system to use them, allowed users to adapt TimeBlocks to many different contexts. Furthermore, the participants mentioned that they paired TimeBlocks with other objects, such as putting the block on a book to show time allocation (i.e., when this block starts, start reading this book) or placing a stack of blocks next to TV (i.e., you can see the TV while these blocks are on). These reports indicate that tangible interface that works with other existing objects could be an interesting research direction.

CONCLUSION

This paper presents TimeBlocks – a novel and playful physical timer facilitating communications between parents and young children. Our field study demonstrates that even young children can manipulate the abstract concept of time easily owing to the familiar interactions of TimeBlocks. We are confident that this paper suggests a new research direction in both child computer interaction and tangible interface and stimulate more research in this area.

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