Bookly: An Interactive Everyday Artifact Showing the Time of Physically Accumulated Reading Activity

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ABSTRACT

We introduce Bookly, an interactive artifact that physically represents the accumulated time of users' reading activity through abstract volumetric changes. Bookly accumulates the time of actions (e.g., picking up and putting down books) that users performed for reading and provides a designated space for the ongoing book being read. The results of our 2-week in-field study with six participants showed that continuous exposure to volumetric changes representing the accumulated time of reading activities helped the users to understand their unsettled reading patterns. Bookly also motivated the users to improve their reading behavior by gradually making reading part of their schedules. Additionally, the definite distinction of the ongoing book improved its visual affordance and accessibility for the users to start reading books. Based on the findings, we confirmed the possibility of making intangible data physical for self-reflection to enhance changes in behaviors that are difficult to perform due to weak motivation.

CCS CONCEPTS

• Human-centered computing → User interface design

KEYWORDS

Book; Reading motivation; Data Physicalization; Self-Reflection;

1   INTRODUCTION

Reading is a well-known activity that can help people in various ways such as by providing knowledge acquisition, mental stability, and linguistic-skill development [4]. However, it is not easy for everyone to incorporate reading into their daily routines. To connect the needs of reading to action, providing motivation to read is important. Based on the literature, to motivate people to read books, goal-setting methods [2], building a family atmosphere [1, 23], and arousing interests by delivering book contents through various digital mediums [14, 19, 29] are suggested. Specifically, previous HCI (Human Computer Interaction) studies have proposed ways to support reading by utilizing a reading companion robot [18], tangible book game [15], and story-related haptic feedback device [28]. They showed how those devices could drive enhancement in reading interest, especially to the people who have weak motivation in reading. On the other hand, methods that will allow users to continuously perceive their individual reading state, which is the basic step in inducing the preparation stage to move people toward the action stage [3, 22], have rarely been studied.

Figure 1: A book that is waiting to be picked up on Bookly

At this point we need to understand the advantages of the physical characteristics of paper books. A paper book's physicality can provide a constant reminder of the book's existence to people in its environment [11] and can express the individual's reading state with its storage form [13, 24].

In this regard, a former study [24] revealed that the storage location and method in the home were directly linked to its topology, that is, as messages informing the reading state. For instance, divided ratio by a bookmark could show the amount of reading progress, or a book that is flipped open and upside down on the bedside table could show that the book is currently being read. In other words, the physicality of books, used for informing the personal reading state, could affect the motivation to read and induce the continuity of reading.

In response to the above issues, previous HCI studies have introduced tangible devices that provide story-related contents of books by combining the functionality of digital books and the materiality of paper books while reading. They promoted interest and engagement in reading through the addition of AR markers printed on book pages [18], the Mixed Reality Book that connects the inside and surroundings of the book [10], and the Magic Story Cube [30] to preserve the physicality of books. On the other hand, the ways of naturally visualizing each step of reading in our everyday lives to provide self-reflection have not been considered, but those studies have focused on the readability enhancement or effective delivery of contents. In this, there were several approaches to provide self-reflection by tracking certain activity and visualizing the collected data to guide the continuity of behavior [6, 8, 26]. Moreover, Thudt et al. [25] suggested designing a self-reflecting tool through the physicalization of the personal data. However, physicalizing the data of the daily book-reading behavior (e.g., putting down and picking up the book) and the value of naturally exposing it around the daily context have not been investigated in those studies.

Building upon the existing studies, we could not only confirm amplifying the materiality of the paper book but also the necessity of exploring ways to store the ongoing book and to deliver self-reflecting data showing the overall reading process in daily life. In this research, we have set our target as busy young adults who have performed small actions such as borrowing or buying books they are interested in (essays, novels, or academic books) but often failed to start reading them. We decided to provide motivation to read for the people who are in the preparation stage of the Transtheoretical Model's 5 stages of behavior change: pre-contemplation, contemplation, preparation, action, and maintenance [22]. This model suggests that, for those in the preparation stage, increasing awareness through a persuasive technology can be a way to encourage them to act. Thus, our motivation for this study was to make a technology-embedded design intervention that would play a role in bringing users to reading action. For this, we designed an interactive everyday artifact, called Bookly (Fig. 1), and observed how it affects users' reading habits in their daily environment.
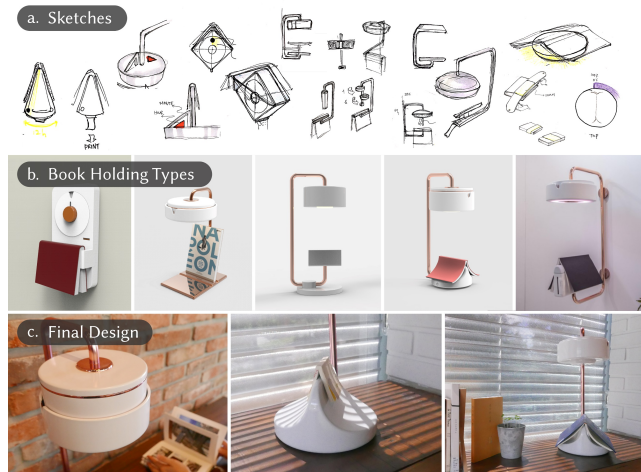
2 BOOKLY DESIGN

The design of Bookly aims to naturally encourage the reader to open the book by exposing the current book being read and physically visualizing the time of reading-related activities. Bookly is a situated timepiece that indicates the accumulation of the book's pick-up time for reading through its vertical and horizontal physical movement of the head. Bookly's main features are as follows:

Physical accumulation of book's pick-up time. Bookly's design began with understanding the purpose of the bookshelf and its role. A bookshelf is not only used to store books but also to expose and provide reminders of the existence of books in the living space. By applying these conventional roles of a bookshelf, we intended to provide a new interaction with the form of an everyday product. Here we focused on naturally connecting the data with reading action through physically visualized reading-related data instead of showing the information of books and their contents [5, 17]. Bookly shows the accumulation of time when the user picks up the book that he or she has chosen to read. In addition, instead of showing the absolute amount such as the number of books or pages, we enabled users to set the reading accumulation's unit as time to let them have different experiences according to their reading amount. Thus, by setting the goal time at the beginning, Bookly shows the relative amount of time through gradual changes of the upper disk volume when the user picks up the book. Through this interaction, we wanted to explore how this method could be linked to our motivation and could affect the direction for the users' reading progress.

Designation of the spot for the ongoing book. If the user places a book currently being read on a bookshelf or with other books, it can easily be forgotten [13]. Additionally, the only communicable part is the spine of the book [17], which is not enough to attract readers. Thus, one of our major considerations in designing Bookly was to provide positional difference between an ongoing book and the others. Through Bookly on the table, we specified the location for the ongoing book, and we connected the input action for the goal time-setting and physical movement output for reading time accumulation. To stop the cumulative time when the users are not reading a book,

a book must be placed on the Bookly stand, and the book will eventually be unfolded in a position that is always visible. Through this, we wanted to know what kinds of new reading experiences could be provided to users by fixing the location of the object (e.g., book) associated with the use of Bookly.

Figure 2: Design process of Bookly. a) Ideation sketches, b) Bookly holding type variations, c) Final design

Based on these design directions, we devised more than 20 concepts with variations of sketches, form renderings, and mock-ups (Fig. 2). We started the process by understanding the various ways of storing books—such as hanging the book on a wall, leaning the book on a stand, or putting the book on a mountain-shaped holder (Fig. 2b). Of those designs, we selected the mountain-shaped holder because it can emphasize that the reading is ongoing, and the reader can easily pick up the book and can avoid unnecessarily damaging the book. Also, we considered a way to merge Bookly's overall shape (Fig. 2c) into the reading context, and we selected a lamp-type form to create a natural reading mood. Last, we designed Bookly's head to physically portray the volume change.

2.1 Use of Bookly

Set-up Mode. First the user selects the book s/he wants to read and then turns on Bookly. Then the outer disk (Fig. 4d) expands to the maximum (Fig. 3a). The user can pick a goal time among four different choices (3 hours, 6 hours, 9 hours, and 12 hours) by touching the button (Fig. 4i) on the side of the lower body (Fig. 3b). This set time will represent the duration until the outer disk reaches the maximum volume. The size of the outer disk's maximum volume is fixed, but the expanding speed changes according to the goal time. After setting, the outer disk lowers to the minimum volume and starts counting.

When the book is removed from Bookly. When the user takes the book from Bookly to read (Fig. 3c), the movement of the outer disk will show the flow of time while the book is out with the user. Users can identify the time through two different movements of the outer disk. One is horizontal rotational movement, which indicates 1 hour in 1 cycle. The other movement is vertical movement (volume change) that shows how much time has been spent from the beginning. Users can notice the starting and the finishing point when the side copper ring (Fig. 4b) of the inner disk meets with the outer disk's needle (Fig. 4c).

When the book is on Bookly. When the user places the book down on Bookly's lower body (Fig. 3d), the outer disk's movement stops. When the user resumes reading, the movement will continue from the stopped point.

Reaching the goal time. When the accumulated time reaches the goal time (Fig. 3e), users can see the maximum volume of the stationary disk with the lightened LED (Fig. 4e) underneath the outer disk. The disk will remain at this position until the user touches the button to reset the time. After that, if the user touches the button, the disk will return to the minimum size, and counting will start again with the same goal time. If the user wants to reset the goal time, the power must be turned off and on (Fig. 3f).
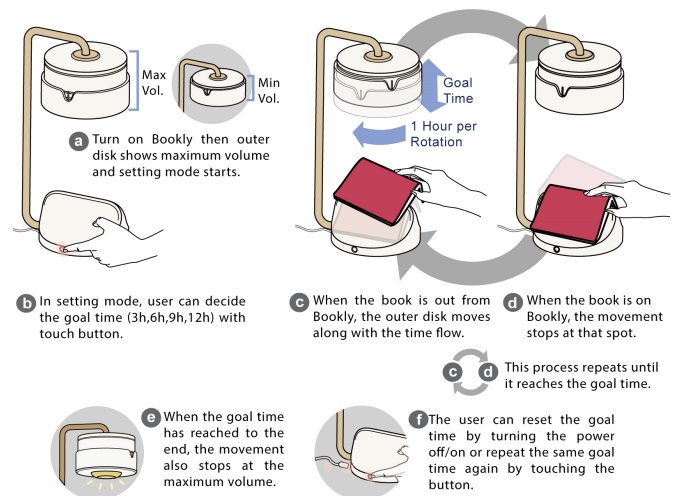
Figure 3: Interaction of Bookly

2.2 Implementation

Overall, the fabrication of our design artifact is meant to enhance its finishing quality and fit the users' environment to be a research product [20]. Also, during the technical development, we have iteratively increased its robustness to be used as an independent device for the field trial. The

head part of Bookly consists of a DC motor (Fig. 4f) that controls the vertical movement and a stepper motor (Fig. 4g) that controls the horizontal rotation. We focused on stably implementing the outer disk case's rotational and volumetric movement at the same time. Specifically, the DC motor for vertical movement was fixed underneath the inner disk's inside ceiling. This motor delivers the rotation to three stud bolts at the same time through a gear to move a round plate up and down. A stepper motor's body was fixed onto this plate, and the rotational part of the motor was connected to the outer disk's floor. In this way, the outer case could rotate and move up and down simultaneously without any fixation on the side. The motors rotated in divided steps over a long period of time, making a sound like a very slow clock. On the floor of the outer disk, the infrared sensor (Fig. 4j) was placed to sense the book's presence. The bottom part contains an Arduino, RTC, and SD card module (Fig. 4k), which were used to save the log data of the book's pick-up and put-down time.
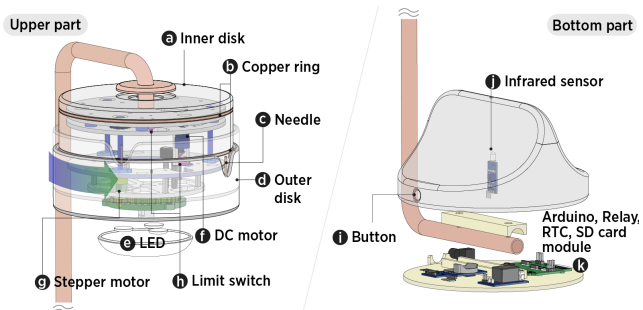

Figure 4: A detailed structure of Bookly

3 USER STUDY

We conducted an in-field study over 2 weeks to look deeply into how Bookly affects the overall reading process in the users' familiar surroundings. In particular, we wanted to know 1) how the volumetric representation of reading progress with an everyday tangible device affects users' reading habits; and 2) how designation of the spot for the ongoing book improves accessibility to the book and continuous reading. We carefully chose 6 busy young adults to be the participants (age 20–28, 2 males and 4 females, P1–P6): 1 startup intern, 1 part-time worker, 2 laboratory researchers, and 2 undergraduate students from 50 applicants. Our criteria for selecting these participants were as follows: 1) People who have started to have their own spaces and time without anyone constantly being involved in their living patterns, 2) people who buy or borrow more than one book per month and perceive the

importance of reading a paper book, and 3) people who tried to read books but failed to start reading and thought their reading amount was insufficient (which is the main characteristic of people in the preparation stage) [22]. The first day of the experiment we installed Bookly in their living spaces, specifically those places they felt were most comfortable for reading and where they spent more than 5 hours a day. P1 (Fig. 5a), P3 (Fig. 5c), and P5 positioned Bookly near their bed. P4 and P6 installed it on their home desk, and P2 (Fig. 5b) chose her start-up office desk.

Figure 5: Bookly in situ. a) P1's room, and fully expanded volume, b) P2's office, c) Reading on her bed in P3's dorm

Consequently, they were able to use Bookly in their natural environment. Interviews were conducted three times: on day 1, day 7, and day 14. Each interview lasted about 40 minutes. The questions for each interview are shown in Table 1.

Table 1. Interview contents following the date

Date	Interview questions
Day 1	Participants' information about reading-related pattern (e.g., reading time, way of keeping books, reasons for reading) and the first impression of Bookly
Day 7	The environment and method of using Bookly. The situation of the book being picked up and the changes to the reading time. Recognition and behavior based on the presence of Bookly
Day 14 (Final date)	Changes in how they use their Bookly. Difference compared to the first week. Changes in overall reading-related behaviors and the reasons for change

In addition, we collected log data showing when the reading started and stopped to analyze the changes in the participants' reading amount and reading pattern. The log data were automatically recorded by the infrared sensor so that it did not interfere with the participants' reading. Verbal data were collected through 631 minutes of interviews. All interview data were recorded and
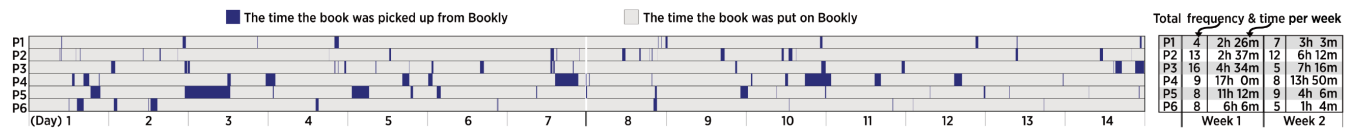
Figure 6: Usage log data of six participants over two weeks (left). The right table compares week 1 and 2's total frequency of the book's pick-up time and the total time after the book was picked up from Bookly

	Week 1		Week 2	
P1	4	2h 26m	7	3h 3m
P2	13	2h 37m	12	6h 12m
P3	16	4h 34m	5	7h 16m
P4	9	17h 0m	8	13h 50m
P5	8	11h 12m	9	4h 6m
P6	8	6h 6m	5	1h 4m

transcribed. They were analyzed through affinity diagramming, and we checked the statements regarding the usage behaviors of Bookly along with the log data (Fig. 6). Through several iterative groupings by our research team, three main topics were finally classified: designated place of ongoing book and its effect, communication with volumetric and rotational movement, and reading progress along with showing accumulated time. Afterward we categorized the similar answers and flow of changes through the usage time among each topic.

4 FINDINGS

During 14 days of use, in total, books were picked up 104 times (first week: 58, second week: 46), and for 79+ hours, the book was taken from Bookly for reading (Fig. 6). These log data were utilized to check the usage time and change of pattern in the interview statements.

4.1 From Volume Change to Reading Habit

4.1.1 Understanding Reading Routine through Messages in Volume Change. We were able to identify what message the volume change of an everyday device was delivered to users in relation to reading. While reading, most participants did not see the movement of Bookly's head. Instead, they checked the changed volume before or after reading the book (N=4) and recognized the change while normally passing around the installed area (N=5). P3 mentioned, *"When I came home from work and faced the Bookly, I felt something because I could see the expanded volume. The needle had stopped. So, 'oh, yesterday I moved it half a cycle. I should rotate it the other half as soon as possible'…"* The five participants stated they felt positive whenever they sensed the difference regarding the message of volumetric change from Bookly. On the other hand, they mentioned that they felt a little pressure when they saw the same volume freeze for a long time, thinking that they should read. Furthermore, with this constantly seen volumetric change and its subsequent messages in their lives, all the participants commented that they could easily see their previously unrecognized or ambiguous reading

progress. P2 mentioned, *"Before… Even though I've been reading a book for about 30 minutes, it didn't come to me as time; I just felt that I had read some today. But, because Bookly collects and shows [the reading time], I could know that I was reading a book in this way."* P5 noted, *"I feel like I could see what I did. Previously, the reading didn't mean a lot to me. I didn't think I read a lot of books, because I read and stopped little by little… But it felt like Bookly was connecting them. So, now I can feel I'd been trying to read a book by myself. It feels good… I feel like reading is now part of my day."* During the interviews, we noted that the participants felt proud not because of the number of pages they had read but because they had read their book and spent effort on reading. This became a self-reflection exercise for the participants.

4.1.2 Settlement of Reading Time within Schedule. After recognition of their own reading routine through the first week, during the last interview, we were able to identify that users started looking for a different way or a right time to read within their existing schedule to improve their weaknesses in reading patterns. We found a common opinion among the six participants. P5 mentioned, *"I started to think about the plan—about the original habit [of reading]. Originally, I did not check how much I was reading because I read from time to time. It felt like Bookly was connecting the reading time by counting (by means of Bookly's outer disk) on and on, so after that I thought that my previous reading pattern was not so good. So, I thought I would like to have more time to read longer, not fragmentarily."* Specifically, P1 and P5 stated they thought about planning out time to read at the beginning of the counting from the minimum volume. In addition, three participants mentioned they had read by finding a certain time, such as, *"when there are few people in the office after work* (P2)," *"before going to bed* (P3)," and *"morning time before exercise* (P6)." Following the log data (Fig. 6), P2 and P3's pick-up number for their book decreased, but the time increased. By matching this with the interview data, this can be understood as the fact that they had found a certain time to read in their routine.

In line with previous studies [3, 9], we could identify the data that reflect one's actions; that is, the volume change of Bookly gave the opportunity to continuously understand his/her reading progress. Moreover, once the user is aware of the inconsistency of his/her behaviors in daily life, it can be used as a motivation for improved behavior [3]. Additionally, this continuous motivation encouraged users to plan the time or context for step-by-step reading of a book. We could also see this is a starting point that can lead to setting a periodic pattern of reading.

4.2 Lowering the Wall toward Reading Activity

4.2.1 Enhancing Accessibility to Ongoing Books. Five participants noted that differing the manner of storing a book and separately positioning the book being read using Bookly could facilitate easy access to a book. P1 commented that she placed the ongoing book on Bookly from her bag after work. She mentioned that she used to not take the book from her bag, even though she carried it home to read. Moreover, the mountain-shaped book holder was one of the triggers for picking up the book frequently. With the stored book shape on Bookly, P1 mentioned that it looked more *"active."* P2 noted, *"It's upside down and spread out... Certainly, I picked up the book more often than the book that I put here (nearby bookstand). My hand reaches here first, and then I feel more like [the reading] is continued."* P4 mentioned, regarding the designated location of book, *"If there wasn't Bookly, I might have put the book away and felt cumbersome, even though I put the book in the same place. And I do not take the book out again once it is put aside. Certainly, [through Bookly] the place [of the book] is fixed, so my hands tend to reach there more often because the space is provided, and it was seen... 'Oh, that book was there'... and I think about the books once more."*

Likewise, all six participants mentioned that if a book is placed in the same place without Bookly, the book will appear as though it was temporary situated there after reading, and very soon it will look like it is not organized. However, they stated that, through Bookly, the book is settled and appears to be arranged. In this way, using the existing message according to the storage shape and location of the paper books [13, 24], the presence of Bookly was able to continuously validate the message that this book is in progress and naturally enhances the accessibility to a book.

4.2.2 Inducing Continuous Reading Activity. Five participants mentioned that they were clearly aware of reading a book after using Bookly and that it affected their continuous reading behavior. Specifically, when P4 saw cumulative time in Bookly, he referred to it as "concentrated time." Five participants noted that the indirect recognition of Bookly's outer disk movement had affected the reading of the book in a continuous way when their book was not on Bookly. P3 mentioned, *"While the book is out, the priority changed from phone to book. It keeps on moving, so I can perceive that. 'That keeps moving, so I should stop using my phone.' 'Oh yeah, I was just reading that book!' I feel like it reminds me of my duty ..."* Additionally, P5 mentioned that Bookly triggered her to continue reading, even if the device was not with her. She stated, *"When the volume of Bookly itself is becoming bigger, the more I felt like I read this book. I went out to read the book, so if it is not recorded... well... it would be not good. I went out without putting [the book] on Bookly [but with a book] on purpose. So, I read it outside more often than before. I was also motivated while I was out, too."* Two other participants also mentioned they read more, even without Bookly, such as between classes (P2), moving (P2), and resting in the office (P3). Moreover, most of the participants stated that they wanted to read their books near Bookly, and a participant who read the book in her bed bought a bedside table and lamp to use next to Bookly. The participants combined other objects with Bookly to make their own reading atmosphere in their space. On the contrary, one participant (P6) noted that he was under the pressure of time when using Bookly until the end and showed a keen response to the counting. We could also see from his usage log data (Fig. 6, P6) that, from the second week of use, he rarely removed his book from Bookly. From this, we learned that time counting in achieving an individual goal requires Bookly to carefully deliver the message to users in a way that is not compulsory.

It has been found that, on the same line with the previous studies [3, 16], after setting the individual goal, the indirect recognition of the time flow may increase the self-efficacy and eventually affect the performance of the intended work [16]. Additionally, Bookly's industrial design element not only affected the participants' reading routines but also influenced their preferred reading spaces.

5   DISCUSSION AND IMPLICATION

Our findings implied that how the physicalization of self-reflected data is shown in an everyday tangible object might motivate natural behavior change.

5.1 Presentation of Self-Reflective Data

Although Bookly is limited in the extent to which it can lead to the maintenance stage (5th stage), we confirmed that Bookly's design could lead the participants who are in the preparation stage (3rd stage) to the action stage (4th stage) in behavior change [22]. In this respect, we found several factors that the presentation method of self-reflective data should include to ensure more effective goal achievement. One is abstract visualization of the progress. Bookly expressed the data in physical volume change without any marked scale. This abstract visualization can provide positive pressure that can lead to natural action for goal performance [3, 16]. Moreover, when showing self-reflective data to drive behavioral changes, it is necessary to choose relative data that reflects the subject's trials, attitudes, and efforts rather than absolute data that only shows the results. We expected that this behavior-inducing method using personal informatics [7] would be able to provide self-motivation for reading and for goals that are not easy to accomplish, although those are perceived to be constructive (e.g., doing exercise, decreasing the hours spent watching TV).

In addition, while reading, one participant felt pressure from Bookly's continuous movement. Based on the interview data, we noted that the participants tended to perceive Bookly's self-reflection quality not while reading but rather immediately after putting the book back on Bookly. Therefore, we could improve this issue of pressure by displaying the volume change when the user puts down the book to stop reading rather than while the user reads.

5.2 Exposure of Physicalized Data in Everyday Life

Physicalizing the metadata [21] of work that must be accomplished, along with exposing tangibly represented data in our everyday surroundings, may become a referent that symbolizes the intended work itself [27]. This can support users to constantly look back on their self-commitment and lead them to change their behavior gradually [9]. In addition, the existence of a physical referent may serve as a means of self-representation, specifically inducing engagement in conversation by publicly disclosing the work users are doing [12, 13, 14].

Furthermore, the above implication can help to improve users' reading patterns of digitized readable content (e.g., e-books, long web articles). By shaping the metadata of digitized readable content into an everyday object, the external visibility of digital reading contents may increase and lead to active awareness of the existence of digital books [9, 12]. This might further affect users' motivation to read digital materials and induce interpersonal social interactions.

6   CONCLUSION

We proposed Bookly, a self-reflecting everyday artifact that interacts through reading process-related action and physicalizes ongoing book pick-up time with volumetric changes. The design of Bookly enabled careful delivery of the user's positive reading behavior patterns in daily life. Through several design iterations, Bookly was designed to emphasize the ongoing book. To ensure that Bookly blends into the real-life environment, we considered constructing a head with well-balanced movement and focused on increasing its finishing quality. The 2-week in-field study drove the natural awareness of the user's reading routine in everyday life. This facilitated self-tracking by continuously offering progress reminders of the reading accumulation time. Followed by this recognition, when the user found a point of improvement in his/her reading behavior, s/he gradually made reading a part of his/her routine and showed the possibility of turning it into a habit. Additionally, the definite designation of an ongoing book improved its accessibility, and while counting the pick-up time, it provided the user a small amount of pressure and increased concentration. Based on the results of our design approach, this opens a new space for developing a self-reflecting interactive device that promotes behaviors that are difficult to perform due to weak motivation in everyday life. Moreover, we can confirm the further possibility of physicalizing data related with intangible mediums such as digital reading contents.

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