Evaluating Tactile User Experiences with Tactile Picture Books for Children with Visual Impairment

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Figure1. Currently available tactile picture book published by the APH

Abstract
Tactile pictures on books are critical to develop literacy for the children with visual impairments and to build strong relationships between them and their parents. While co-reading storybooks, parents and the blind children can actively communicate by touching and feeling tactile objects on a page. We describe two tactile storybook prototypes we have created. We discuss two tactile UX evaluation techniques for measuring how children touch tactile objects and for recording how parents and children talk about the story as facilitated by our tactile storybooks.

Author Keywords
Children; Blind; Tactile Pictures; Accessibility; 3D Printing; Evaluate; User Experience

ACM Classification Keywords
Design; HCI; Human Factors; Measurements

Tactile Story Books for Blind Children
Tactile book creation
Tactile books have been created manually. The significant portion of currently available tactile picture books in the States is published by the APH, American Printing House for the Blind. Figure 1 shows an example of currently available tactile book. However, the variety of the book choices and replicability of it are limited, because current tactile books are created by hand. Handcraft method keeps parents from accessing a wide selection of books for co-reading, since this manual process requires huge amount of effort of artists and a lot of time to copy books on demand, making itself expensive.

3D Printing
3D printing is an emergent technology that has become increasingly affordable. We believe 3D printing holds the key to economical creation and reproduction of tactile books. It presents possibilities of a home-DIY manufactured tactile picture book. Imagine the case of

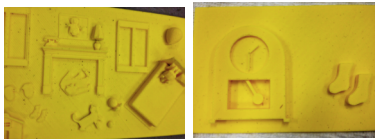**Figure 2.** Handcrafted tactile picture book pages we made.

Figure 3. 3D printed tactile picture book pages we made.

Crafting	3D printing
fabric, fur, beads, felts, soften wire, silicon etc.	Plastic (PLA, ABS) only
- Hard to create and maintain, - Not replicable + Rich textures are expressed with vary materials	- Hard to render - Poor representation of textures + Easily modifiable + Replicable, easy to share

Table 1. Methods and materials experienced, pros and cons of preliminary study

a mother and his blind son. The mother visits a bookstore near her home and buys a regular children's book describing different kinds of car, based on her son's interest. At home, she simply takes a picture of a page with her smartphone, sends the picture to a 3D printer, and the printer simply prints out 3D tactile motorcycle, dump truck, and bus, etc. She can enjoy "reading" together with her blind son.

Co-reading Experience
For children with visually impaired, co-reading a book with their parents gives them unique and efficient help to develop literacy by getting additional information about context. Also, this helps them to build strong bonds by letting parents to learn which stages their children are currently, to realize children's needs and interests, and to decide the appropriate education level. These processes are essential for parents to understand their children, because every child is unique. [1]

Preliminary Works

Hand Crafted Tactile Picture Book
We created the first tactile book by translating *Polar Bear, Polar Bear, What Do You Hear?* We chose this book because each page of the book represents an simple animal and the sound it makes, to get a concept of the animal easily. Figure 2 shows example pages. We used various materials such as leather, foam, etc. to enhance children's touch experience with rich textures, since those features help children with visual impairments to develop literacy [2]. Table 1 shows pros and cons of experiments. Parents can mimic sounds the animal makes when they co-read the book, enable their children to learn an animal's texture at the same time.

Figure 4. A page in *Goodnight Moon* (left) and its tactile translation in a 3D model viewer (right).

3D Printed Tactile Picture Book
Our second trial was done by 3D printing, which is a tangibly translated version of *Goodnight Moon*. We created 3D scenes describing story using the Google SketchUp and a 3D warehouse digital library users of it share 3D object they rendered (e.g. bed, balloon, etc.). Figure 4 shows the screen view of tactile picture. 3D printing promises us customizability, replicability, and scalability. This book was chosen because (1) an artistically made version of it is already available to compare with our work, (2) it has various picture scenes we can introduce one or two simple objects per page children see in daily life, (3) the story of the book is to let a parent lead a child to say "Good Night" to each object by touching it, engaging interaction among the child, the parent, and the book. Figure 3 shows example pages of the 3D printed book.

Co-reading Experience with Tactile Picture Book
We have published our initial two prototypes of tactile books on our project website[1] to share with the community. We have received requests from and sent "copies" to a wide range of stakeholders including parents who have blind children, as well as parents of sighted but still young children, school librarians, NGOs,

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[1] www.tactilepicturebooks.org

tactile translator, and professors and PhD students in various disciplines (Computer Science, Psychology, Art and Design). One of parents who got our 2 pages of prototype sent us a video, recorded active learning experience happening between her and her 2 year olds young daughter.

What children with visual impairments and parents talk during co-reading?

Where is the point of touch when they co-read context?

Figure 5. A child with visual impairment (middle) is touching a page in our tactile storybook while talking with her mother (left) and a member of our research team (back) at the Anchor Center for Blind Children.

In addition, we brought these prototypes to the Anchor Center[2] for Blind Children for evaluation and feedbacks, a preschool for the blind children in the Denver area, Colorado. We have worked with Anchor since the beginning of this project to create novel method to educate them. This partnership allowed us to observe usability and user experience of our preliminary works and to see what we need to improve in order to enhance their learning and interaction between them and parents. Figure 5 shows co-reading the tactile book.

[2] www.anchorcenter.org

Evaluating Tactile User Experiences

Participation

Our tactile picture books are designed to offer tactile user experiences, where users are children with visual impairment. To evaluate these books properly, we need a method to allow for qualitative and quantitative evaluation without interfering with a child's and his/her parent's experiences with these books. This need aligns perfectly with the objective of the "Touch Me" workshop.

Every kid is unique, so that all children with visual impairments are in different development level of literacy. Therefore, we must consider all these needs in order to improve the next tactile picture book design. The research questions we must consider include:

- How can we assess cognitive level of our books for those who are lacking literacy and cognitive abilities?
- Which methodology will help us to get interaction data between physical object and readers?
- How we can collect situational reaction and needs without words?
- Can data collected from sensors represent interaction between the book and readers?
- What are the limitations of current evaluation methods of tactile interactions?
- Which new method we must develop, in order to collect tactile?

Prototype

We are currently developing and comparing two evaluation techniques that may give us the qualitative and quantitative UX data on how children and parents co-read and interact with our tactile picture books.
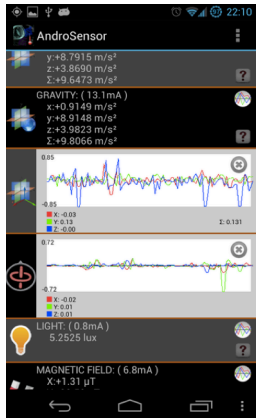
Figure 6. AndroSensor mobile application to collect sensor data from the smartphone
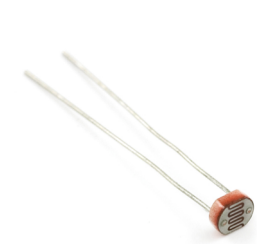

Figure 7. Mini photocell to detect the shadow of light. It will determine which position was hided(touched) by hands of children

Sensors in Smartphone

The first technique is easy to implement, which is to attach a smartphone to the back of a tactile page and record the sensor data, while parents and children interact with the book. We installed AndroSensor application and attached the phone to the tactile book to collect all sensor data, such as x-,y-,z-values indicating children's motion while reading the book. Figure 6 shows the screenshot of AndroSensor app.

Special Circuits to get specific data

The second technique is to 3D print a tactile page with attachment points to install touch resistive sensors, which can give us data on the pattern of touch (e.g., how long, where, in what order). Figure 7 shows example sensor we could use for the circuit. The circuit board connecting these touch sensors can also be printed as a part of the 3D tactile picture production process.
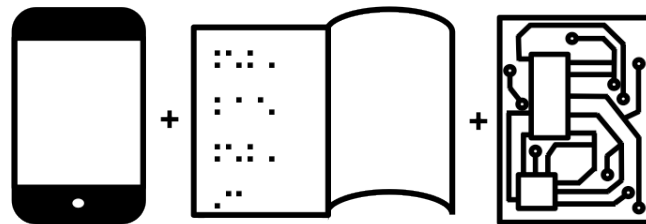

Figure 6. Combining smartphone, tactile books for the children with visual imparements, and the circuit board

Post Observation

We hope the combination of the two techniques will enable us to shed light on the following questions regarding tactile user experiences:

- Where and which objects readers mostly touch on the page?
- Is the point of touch relative to words and context of the story?
- What readers talk about when they touch on pages?
- How readers move or tilt the book?
- Is this movement and mobility essential for their reading experience?
- What makes the tactile book accessible for the children with visual impairments?
- From which element of the tactile book readers want to improve?

Participating in the "Touch Me" workshop will allow us to network with and get feedback from the tactile UX community in order to adequately address these questions and better serve the children we care about.

Acknowledgements

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