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# Tactile Picture Books for Young Children with Visual Impairment

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## Abstract

Tactile picture books are critical to the literacy skills and emotional development in young children with visual impairment. We report a formative study on new methods for designing and creating tactile pictures. We present two tactile picture books created by handcrafting and 3D printing respectively. We report evaluation of these books by experts, outcomes of our participation in a tactile picture book competition, and encouraging feedback from people in the general public who received copies of our books.

## Author Keywords

Children; Blind; Tactile Pictures; Accessibility; 3D Printing

## ACM Classification Keywords

HCI, Design, Experimentation, Human Factors

## General Terms

Tactile Pictures, 3D printing

## Introduction

Tactile graphics and tactile books are critical to the cultivation of the parent-child relationship as well as emergent literacy skills and emotional development in young children with visual impairments. Figure 1 shows an example of tactile picture book.



**Figure1.** Small toy-like current tactile pictures

Like early reading experiences with any child, books provide a medium for interaction between a parent and their child. Co-reading experiences enable parents and children to make emotional bonds, relate to one another about their surrounding environments, new environments, objects, and relationships, as well as expand creativity and vocabulary and instigate new conversations. Furthermore, these interactions inform parents about their child's learning needs, styles, and progression into literacy.

For children who are born with or who acquire visual impairments, these co-reading experiences require an additional layer of tactile information to make the content of books relatable and legible. On the contrary, tactile picture books also aid in the development of a child's tactile acuity, their sense of seeing or feeling of their environment, as well as the confidence to explore and build relationships and associations through touch.

#### *Tactile book creation*

For centuries, tactile pictures have been created to convey graphic information in a tactile way. Today, in the United States children's storybooks with tactile pictures are available through publishers like the American Printing House for the Blind (APH).

The creation of tactile pictures requires visual pictures or experiences to be transcribed in a way that a child natively relates to the content or is able to associate the represented object to the real world experience. Furthermore, the production process is often time and resource intensive, and requires experience with

digital software and/or handcraft skills. Even when a parent succeeds in creating a book for her child, a sizable amount of time and resources are needed to duplicate the book, reproduce the book with small amendments, or economically share the book with other parents or teachers of the visually impaired (TVI).

#### *3D Printing*

3D printing is an emergent generation of pervasive printing technology. It presents a unique opportunity to simplify the creation process of tactile books—even to the extent that parents can design and manufacture tactile books at home. The vision of this project is to enable parents of children with visually impaired children to use 3D printers to fabricate custom tactile picture books to read with their children at home. Imagine a father and his blind daughter. The father visits a library and checks out a children's book. At home, he takes a picture of a page in the book, sends the picture to a 3D printer, and the printer simply prints out a 3D tactile model he can enjoy "reading" together with his blind daughter.

This scenario hides the internal technical process that is required to convert the image to a printable 3D file. First, the image needs to be processed to extract important objects. Each object needs to be identified (e.g., cat or human). A suitable 3D model needs to be retrieved from a royalty-free 3D model repository (e.g., Thingiverse.com) to represent each object. A collection of such models needs to be arranged into a page. Each step in this process is a difficult problem that must be solved.



**Figure 2.** Examples of tactile pictures created by currently available methods. Raised lines and shapes (above), flat shapes overlaid (below)

This extended abstract reports our *work in progress* toward fulfilling this vision. To date, we have started a foundational study to explore the need/problem space, before we tackle the hard problems. We conducted a study on printing methods and materials and followed up with another study on design methods - handcrafting and 3D modeling, created two tactile picture books based on children's book classics, obtained feedback from experts, participated in a tactile picture book competition, shared copies with the communities, and received encouraging responses.

### Background and Related Work

APH plays an important role in making pictures accessible to blind people of all ages, including children. APH has identified five major types of tactility: (1) objects or parts of objects (2) forms of objects (3) flat shapes, (4) raised lines and shapes, and (5) raised lines and dots. [1]

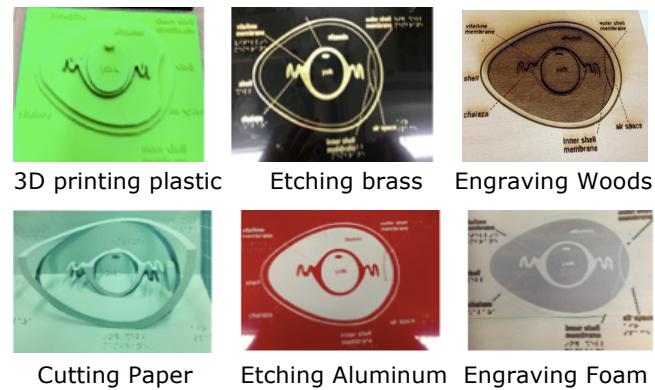
Figure 2 shows two examples of current tactile pictures. In the top photo, molded plastic sheets or thick paper are used to depict a shape of the object with layers of material. The lower photo shows that an abstracted diagram image of an object can represent one specific perspective of the object. Raised lines and dots are also efficient method to distribute area, if drawn areas are filled with raised dots from the flat background, like visual coloring contrasts.

### Printing Methods / Materials

In our initial study, we have explored the pros and cons of a variety of materials typically used to make tactile picture books. For our initial testing of materials, we selected a diagram of an egg from a children's book on science. We tested four printing methods in combination with five materials to turn this

picture into various 3D tactile models. Examples of the models we made are shown in Figure 3. The printing methods we tested include 3D printing, etching, engraving and overlaying, and popup origami (paper cutting and folding). The materials we tested include plastic, wood, painted brass, aluminum, and foam.

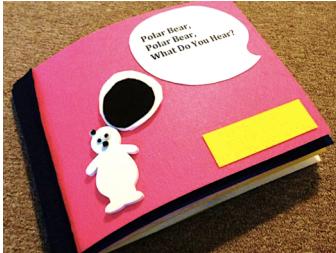
Table 1 and 2 summarize our preliminary findings on the pros and cons of these printing methods and materials that Figure 3 shows as combinations.



**Figure 3.** Combinations of methods and materials

3D printing	+ Mostly tangible + No limits on thickness of base - Longer processing time
Etching	+ Thin and portable with metals - Hard to get materials in daily life - Risk a sharp edge
Engraving	+ Effective representation for different depth of each region - Iteration needed to make depths
Pop-up Origami	+ Relatively simple to create - Manual folding, hard to express details

**Table1.** Pros and cons of four printing method



**Figure 4.** Example pages of handcrafted tactile picture

Plastic	+ Thin and light - Fragile if too thin
Wood	+ Various adaption of power, speed, and frequency (DPI) - Danger of combustibility
Painted Brass	+ Smooth and neat engraving on surface - Subtle differences of engraved area - Risky settings needed for laser etching
Aluminum	+ Etched deeply than other metallic + Textures can be represented - Hazardous dust during etching
Foam	+ Dramatic texture difference according to settings difference + Light and safe - Easy to shrink by laser heat

**Table 2.** Pros and cons of five materials

### Design Methods

In our second study, we explored two tactile graphic design methods: (1) hand crafted method and (2) digitalized method, especially 3D printing, in order to gain understanding about the challenges people may face during the creation process.

#### Handcraft Method

The first design method we explored was the handcraft method, which is a common practice. [2] An artist is commissioned to take a children's book and handcraft a series of tactile pictures to retell the pictorial content in the book. We tested this method based on a children's book classic *Polar Bear, Polar Bear, What Do You Hear?*. Each page of the book simply features an animal and the sound the animal makes. To enable tactile interaction with the animal for blind children, we implemented not only textures and vivid color contrasts, but also electronic sensors and music shield boards. To make the animal sound audible, we installed

touch sensors and small speakers, so that each animal on the page generates its unique sound if a child touches the page, making the book more interactive. Figure 4 shows examples of 6 pages of tactile pictures.

#### 3D Printing Method

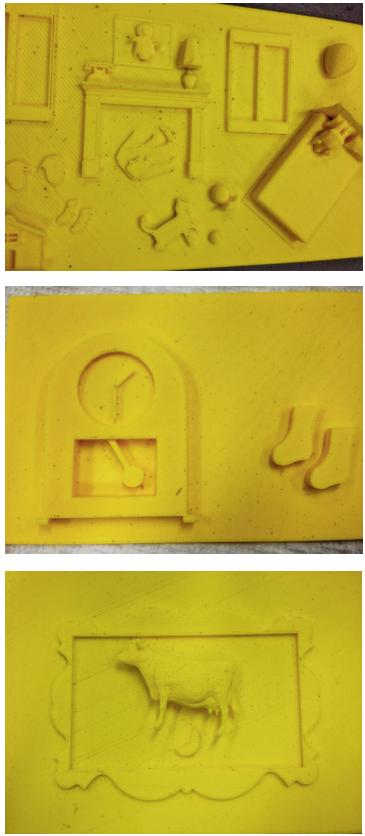
The second method we explored was the 3D printing, an emerging technology that promises customizability, replicability, and scalability. We experimented this method based on another children's book, *Goodnight Moon*. We chose it because an artist-rendered tactile version of the book already exists, providing a baseline for comparison. The story is centered on an indoor scene with various furniture pieces and objects, to each of which a child can say "Good Night".



**Figure 5.** 3D file view for printing tactile pictures

To translate the scene into a tactile picture, we first used Google SketchUp to construct a 3D scene. To place an object on the canvas, for instance, a bed, we searched the 3D Warehouse and Thingiverse, for a suitable model to represent an appropriate perspective of it. We imported this bed model on the canvas, resize it, and repeated for others in the scene. The figure 6 shows an original scene and the resulting 3D tactile model we created.

After the model was created, we converted the model file into a 3D printable format (i.e., stl) and sent it to a high-resolution 3D printer (i.e., Stratasys Dimension) to print. A typical model took about 3 hours per page



**Figure 6.** Example pages of 3D printed tactile picture books

on average to print. We created a total of 12 tactile pictures. We then bundled them into a book. The figure 6 and 7 show examples of individual tactile pictures and the resulting book. Note that on the left side of each page, we printed the text from the original not only *as is* but also *in Braille*. Even though our target audience of blind children is too young to read, text is important to support co-reading with parents, and early introduction of braille supports later learning.



**Figure 7.** A complete page of 3D book with braille

### Evaluation by Experts

We invited two experts in the field of teaching for the visually impaired to visit our lab. They have been studying and working with blind children for more than 20 years. They examined the tactile pictures we made during the pilot studies. They suggested that we create a concept book, which describes daily activities. For example, we could make tactile pictures for a spoon, a table, a bowl, etc. for the "eating" situation. With these pages, parents could introduce context of eating to their blind children and explain the relationship between the object and the everyday situation. They also recommend considering transcribing an object that required movement by the child, as a way of teaching mobility and objects that have multiple parts. For example, they recommended fabricating ingredients of a hamburger.

### Tactile Picture Books Contest

We entered both tactile books into the Typhlo & Tactus tactile book competition (2013). This contest is held and evaluated every two years. Participants from all over the world compete at the regional level. Finalists from each region then compete at the international level.

The outcome was encouraging. Our tactile version of *Polar Bear, Polar Bear, What Do You Hear?* was chosen as one of the five finalists from the US to participate in the international level of the competition. The judges liked the rich variety of textures we used and the simple storyline that focuses on sounds, which are appropriate for a young blind child. They also commended that we were the only participants coming from outside of the field of education or TVI.

Although our 3D printed version of *Good Night Moon* was not selected as a finalist, it generated a high-level of interest among the judges. They found that 3D printing holds "very interesting possibilities" and encouraged us to "keep exploring it." There were two major concerns. The first was that plastic models are harder to interpret than rich textures. To address this concern, we must look into ways to 3D print textures as well. The second concern was related to the complexity of the models we made. Because we tried to replicate as much original content as possible, our tactile picture of the indoor scene faithfully includes all the objects from the original (e.g., fireplace, rocking chair, socks). The judges recommended that "only one or very few objects" should be shown on each page.

### Sharing with Communities

After we created our first 3D printed tactile book based on *Goodnight Moon*, we published the results on our

project website<sup>1</sup>. Since then, we have received many emails from people in the general public who wish to obtain a copy of the book. To honor their wishes, we printed an abridged version of the book with only two pages and mailed the book to them. Having learned from the experts and the judges about the importance of simplicity, we greatly simplified the content. The first page has just a single cow and the second page is an abstraction of a toy house and a mouse, shown below.



**Figure 8.** Two pages of the prototype we shared

Requests came from parents who have blind children, as well as parents of sighted children, school librarians, NGOs, and professors and PhD students in various disciplines (Computer Science, Psychology, Art and Design). After obtaining the 3D printed book from us, a number of the recipients wrote back to thank us and told us how they used the book. A professor told us about the plan to use our tactile pictures in a class, expecting that these tactile pictures could “appeal to students to find their future goals working with kids who need special help.” A mother sent us a video showing how she co-reads our book with her child.

### Future Works

We created tactile picture scenes based on the shape of objects. However, we still need to manipulate textures

<sup>1</sup> <http://www.tactilepicturebooks.org>

as suggested earlier. We consider generating affluent textures using 3D printer, to provide different touch experiences such as comb and brush.

To transform 2D pictures into 3D-printable files, we need to recognize objects from the scene and complete missing perspectives of the 3D object to automate this conversion process. For example, although we recognized the front perspective of a bed from a room picture, we still need to imagine the other side of the bed.

Every child with visual impairment is unique, meaning they have different interests and development. In other words, parents need to change the size, number of objects per page, and the level of abstraction. First-hand kids need more simplified tactile picture, while older children may want to explore refined and detailed tactility. We are investigating a computationally enhanced way to enable parents to customize tactile books at home.

### Acknowledgements

We thank all the parents, professors, TVIs, APH, judges of the T&T contests for their support and feedback on our research effort, to make tactile picture books more available and accessible to young blind children, thank Cassidy Fianagan for giving us permission of tactile translation of *Goodnight Moon*.

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