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ABSTRACT

Through the use of an on-line questionnaire and in-depth observation sessions, we examined how people produce tactile graphics (raised images that are designed to be read by the fingers) for blind students and how they use software applications during tactile graphics production. We found that tactile graphics specialists shy away from using applications, even though their production methods are labor and time intensive. Half of the participants did not use a computer at all and those who did relied upon simple drawing functionality, such as Microsoft Word's drawing tools, as opposed to fully featured drawing systems like Adobe Photoshop or Illustrator. Participants considered fully featured drawing systems to be cumbersome, non-intuitive, and overkill for their needs. Nonetheless, these tools have valuable image processing algorithms, which could help them to streamline their work practices. Bridging the gap between their current and new software-based practices is an interesting human-computer interaction problem. The cost of not addressing this HCI problem is tremendous, because over 93,000 school-age children will be left behind.

Author Keywords

Tactile graphics, image processing, user interface design

ACM Classification Keywords

H5.m. Information interfaces and presentation: Miscellaneous.

INTRODUCTION

Historically, blind students have been denied access to important graphical materials which their sighted counterparts can access. It is easier and less costly to simply leave images out of a textbook than to have a tactile version of it created by a tactile graphics specialist. At the University of Washington, one detailed map of the campus cost the school $10,000. A student may check it out, but she must return it. Furthermore, online campus maps are updated every three months, but the same tactile campus map has been in use for the past seven years.

There are several obstacles to the timely translation of graphical images into a tactual format: labor-intensive and slow reproduction speed, poor graphic reproduction, inadequate resources, and variation in transcriber expertise. Without innovations to address this problem, the over 93,000 school-age, visually impaired or blind students may not have access to certain careers, such as math, science, and engineering (MSE), due to the heavy reliance on graphical images within these fields.

This report describes a contextual inquiry into the process of creating tactile graphics. Our goal is to assist transcribers, who are mostly volunteers or poorly compensated, in transforming, as automatically and intelligently as possible, graphical images into a high-quality tactual form that can be reproduced and then used by students. Our study shows that to accomplish this goal, first, a complex human-computer barrier must be addressed: Transcribers encounter multiple, complex, and inconsistent user interfaces when they carry out tactile graphics production with current software applications.

There are several related studies of transcribers; however, most studies mainly examine how many transcribers there are (e.g., [1, 2]) and their training [3]. We used these studies to develop domain knowledge and to inform the design of our contextual inquiry. We are not aware of any other study, which examined the work practices of transcribers or the software which they use.

RESEARCH METHODOLOGY

Through the use of an on-line questionnaire and in-depth observation sessions, we examined how people produce tactile graphics (raised images that are designed to be read by the fingers) for blind students and how they use software applications and hardware during tactile graphics production. The questionnaire consisted of 34 questions, which explored their training, work practices, hardware used, and software used; we also collected demographic data (age, computer experience, gender, race, and so on). We recruited transcribers through email discussion lists for the Braille community and via letters and phone calls to organizations which produce tactile graphics.

We conducted sixteen in-depth observation sessions with tactile graphics specialists in the Pacific Northwest, California, and Kentucky. We videotaped participants as they completed transcription tasks within their workplaces; we asked them to talk aloud about their thought processes and actions as they worked. We asked participants to complete three control tasks: (1) translate or transcribe a one-page text document, (2) create a tactile graphic for a diagram of the human eye (see Figure 1), and (3) create a tactile graphic for a bar chart. We chose complex images to examine how participants currently handle challenging media and to have them to use as many resources (hardware and software) as possible. The images were standard diagrams found in college-level MSE textbooks.

This report focuses on our questionnaire analysis, preliminary findings from the observation sessions, and an evaluation of the software tools used by transcribers.

QUESTIONNAIRE RESULTS

There were 51 responses to our questionnaire. Results suggest that tactile graphics producers are a fairly homogenous group. They tended to be female (93 percent), and, perhaps due to the nature of their jobs, 96 percent had no physical or cognitive impairments. They tended to be Caucasian (80%) and in their late forties or early fifties (median age was 48). They had completed some college coursework (31%), and 21 percent were college graduates. English was their first language (82%).

Transcribers traditionally receive low pay and recognition. Full-time, certified professionals earn about \$18,000–\$50,000 a year, while non-certified professionals earn \$10,000-\$30,000 a year [2]. Respondents tended to not be certified. If they were certified, their certification was typically through federal agencies (37%), state agencies (27%), and transcription organizations (17%). Most stated that they acquired tactile graphics production skills from on-the-job training or were self-taught.

Tactile graphics producers tended to be full-time employees, but not all named transcription as their primary role. Most respondents (65 percent) characterized themselves as transcribers and with no other roles. Other roles included: paraprofessionals (20%), teachers of the visually impaired (12%), tactile graphics specialists (12%), educator/trainer (10%), assistive technology specialist (8%), and administrator (2%). Tactile graphics producers had six or more years of transcribing experience, with 55 percent reporting that they had over 11 years of experience. They had at least 11 years of computer experience, but their equipment was under-funded and not updated for many years.

Tactile graphics producers mainly worked within school systems (55%); a few also had personal businesses. They mainly worked on text (92%), graphics (90%), and math (82) transcription tasks. They produced: textbooks (90%); graphs, charts, and other graphics (92%); literary works (78%); foreign language materials (57%); and children's books (63%). They used a variety of methods to make tactile graphics; most tended to use swellpaper (51%), embossing (40%), and thermoform (39%). They used various image-editing software applications, with most using CorelDRAW (20%). Some respondents (39%) did not use any image-editing software. They used multiple hardware solutions to create images, including foil (20%), the Tactile Image Enhancer (16%), Versapoint Embosser (15%), Tiger Embosser (14%), and Juliet Embosser (12%).

RESPONDENTS' FEEDBACK ON IMAGE-EDITING APPLICATIONS

We asked respondents about the image-editing software that they use currently or attempted to use. Specifically, we asked them if there were ways in which the software could be improved to better support their work practices. We also asked them about additional software features that could be beneficial in the creation of images like charts, diagrams, and maps. There were a wide variety of issues that they mentioned. Comments related to the most frequently used software packages: Microsoft Word (9 comments), Adobe Illustrator (2 comments), CorelDRAW (3 comments), Adobe Photoshop (1 comment), and Tactile Graphics Designer Pro Pad (TGD Pro; 1 comment). The latter tool is the only image-editing program that was made specifically for the tactile graphics production community. We present some specific software issues below, based on questionnaire responses. We gained additional insight about the software during our observation sessions.

An unusual surprise from the questionnaire and the observations was how much praise Microsoft Word received. We had not considered that Microsoft Word would be used as a tool for making tactile graphics, but respondents were clearly afraid of using image-editing software; they perceived fully featured software to be too complex or lacking specific features for the transcriber community. Our comparison of software tools in a subsequent section provides more insight about this issue.

Respondents provided general comments about how software could be improved, although their comments were not associated with a specific application. They wanted more templates and a repository of images from which they could work. They also wanted more texture fills, better translation of text within images, better image detection and auto color contrast, better support for 3D graphics production, better compatibility across software applications, and effective documentation and help aids.

PROFILE OF A TACTILE GRAPHICS PRODUCER

Based on our analysis of the questionnaire data and observation sessions, we created personas of tactile graphics producers. We plan to use these personas during our next research phase, in which we will design an automated image-editing application to reduce the time spent on creating and editing images for tactile graphics production. Below, we provide a shortened persona.

Sue Beres is 50 years old, Caucasian, works in a middle school, and is a full-time employee. She uses the Duxbury Braille Translator and Microsoft Word. The hardware she uses is the Juliet Embosser, the Tactile Image Enhancer, the Perkins Brailler, and craft supplies.

Sue has had some college classes, mainly specialized trainings and workshops pertaining to her work. She mostly works alone in a small office, but sometimes she consults with her supervisor in the district's accessibility department. She is certified by the state of Washington in Braille translation and tactile graphics production so that she can work in the school system. Sue translates text to Braille and makes tactile graphics and 3D models for two students in the school district. She has been working with the same three students for several years and will probably follow them on to their high school.

Sue uses many methods for making tactile graphics. The method she chooses depends on the skills of the student and the complexity of the graphics. Sometimes she makes models of graphics that would be difficult to explain in a two-dimensional format. For example, she would make a model of the human eye or see if there was one she could borrow from a science class. She also has a large supply of craft materials to make different textures on paper, including a waxy material that comes in sticks (Wikki Stix) and some materials from her home sewing kit. She has a Perkins Brailler to type labels and paste them onto diagrams and she has a Tactile Image Enhancer to thermoform some images. She has just discovered that the drawing tools in Microsoft Word can make simple diagrams and charts, but she still creates the majority of tactile graphics with her craft supplies.

Example Transcription Task

Figure 1 depicts one of the two images that we used during observation sessions, and Figure 2 demonstrates a typical transcription task completion sequence that Sue may follow during the image's tactilization. Each rectangle in Figure 2 represents a subtask along with the time spent on it; the text under each rectangle reflects the

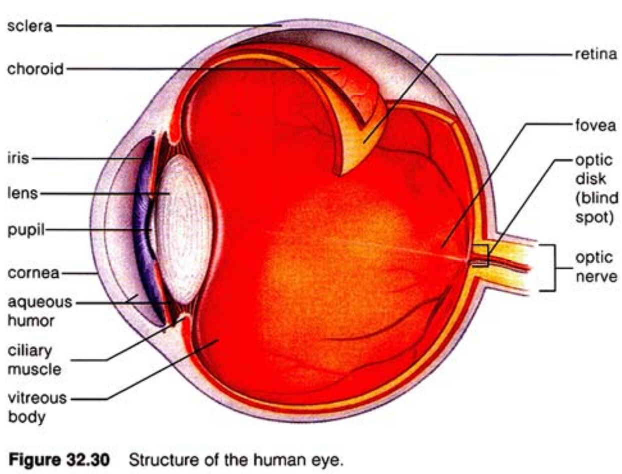

Figure 1. Image used for the observation sessions.

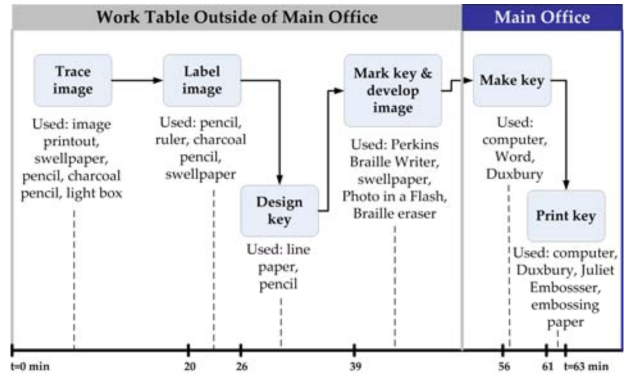

Figure 2. Example image translation task completion.

resources used during the subtask. Figure 2 shows that creating tactile graphics is labor and time intensive. Creating tactile graphics can involve the use of many tools and there is much room for improvement.

Figure 2 demonstrates how one participant actually created a tactile eyeball (Figure 3) and the Braille key to accompany it. The transcriber not only used an assortment of software and hardware, but she also needed to work in two different rooms. This behavior was typical during all sixteen observation sessions. There were embossers and hand tools to do things which computers cannot do. Tactile graphics producers understood that one method could not perform all required tasks.

Automatic text translation and embossers save transcribers a lot of time. Without software or hardware support, they would have to do everything by hand, and it could take much longer. Current practices are much faster than they used to be; however, it appears that each new product was made to perform specific tasks, without looking at their overall work practices. For instance, each tool can only be used for a specific subset of the entire task (Figure 2). These work practices need to be streamlined, and better software needs to be designed so

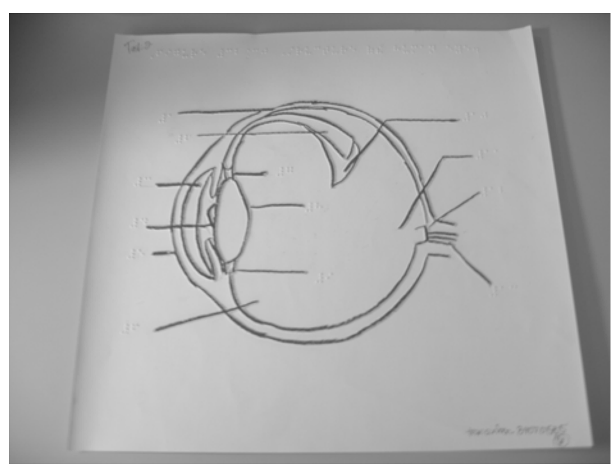

Figure 3. Example tactile graphic produced.

that the tactile graphics production community can comply with federal mandates with respect to providing students access to these educational materials.

SOFTWARE EVALUATIONS

Text Translation Tools

Tactile graphics producers who worked with large amounts of text used two applications: Duxbury Braille Translator and Microsoft Word. Word has various text editing and formatting tools. It has drawing tools and supports embedding graphics in documents; this feature helps them to incorporate graphics into Braille texts. It is available readily on most desktop PCs, and a large amount of documentation and training is available to help users to accomplish tasks. Word has no support for Braille documents other than Braille character fonts. The tactile graphics producers whom we interviewed could only use Word to represent Grade 1 Braille, though they preferred to use Literary Grade 2 Braille in publications for adults. Despite its powerful tools for editing text and creating text layouts, Word is not well-suited for working with large amounts of text in Braille.

Duxbury contains powerful tools for text translation. It supports a variety of Braille styles, including Literary Grade 2, mathematical expressions, and Braille codes in many languages. It has some page formatting capabilities and proofreading tools, as well as support for embossing printers. Nonetheless, it has poor support for embedding graphics into Braille texts, and it has little support for specially formatted text like tabular data. Its interface is also difficult to use. Transcribers often use Duxbury in conjunction with Word. Duxbury succeeds at translating large portions of plain text, and Word is useful for special page formatting and embedded graphics. Neither program contains an adequate set of tools for translating a publication which uses both text and graphics.

Image Translation Tools

Commonly used image-editing applications were Adobe Photoshop, CorelDRAW, TGDPro, and the drawing tools within Microsoft Word. To evaluate the suitability of these tools for a typical graphics creation task (Figures 1 and 2) and tactile graphics producer (see profile), we recreated the bar graph that we used in our observation sessions. We compared the user interfaces and task completion sequences within Adobe Photoshop CS, Adobe Illustrator CS, CorelDRAW 12, and Microsoft Word 2003.

The programs had some similarities user interfaces and core functionality. All tools had: a shape tool to draw the bars; a way to arrange the bars in a uniform graph shape; a method to change the bars' fill and line properties; the ability to add text labels to the graphic; and a way to delete elements. Most had a way to export images out of the program. None of the programs had support for Braille, other than the use of a Braille font.

Each program required substantially different methods to accomplish certain tasks. No two programs had similar interfaces for applying a fill pattern or saving the finished image in a format that could be used in other programs. Though the programs all contained the same kinds of core functionality, the tactile graphics producer had to use different methods to complete tasks; these differences contribute to the learning curve of each program and the difficulty of using several programs cooperatively.

Some of these differences pose serious barriers to tactile graphics producers' capabilities and productivity. For example, CorelDRAW, Illustrator, and the Word drawing tools are vector applications that are based on manipulating geometric shapes. Photoshop is designed to edit high-complexity bitmap images, with little control over shapes. Photoshop has moderate support for vector shape editing, but the interface is dissimilar from other vector applications. Older versions of Photoshop have no shape control, other than placing each object on its own image layer. For this reason, it is time-consuming and difficult to manipulate geometric shapes for tactile graphics in Photoshop.

Rather than representing image areas with color, they apply different patterns of dots and lines to the shapes, which the printer can then raise into different textures. However, most of the programs (CorelDRAW, Photoshop, and Illustrator) only offer fill effects that are too detailed for embossing by a Braille printer. Word offered a collection of simple geometric patterns that, while less appealing in illustrations for sighted people, would be appropriate for Braille printing.

TDGPro was developed specifically for tactile graphics producers; however, it was not frequently used. In our observation sessions, participants complained about the available documentation and interactions with TDGPro's support staff. They said that they had trouble installing the software and with using TDG TagPad, which is a drawing tool that works with TDGPro. We experienced the same problems when we attempted to evaluate the tool; for instance, we were unable to install it. It appears that TDGPro does not serve effectively the needs of the tactile graphics production community for which it was developed.

Surprisingly, because its primary purpose is not to be a graphics program, Microsoft Word turned out to produce the best results in our evaluation. In addition to having the best selection of Braille-usable fill patterns, it produced clean shapes and its grid feature produced the most precise alignment of the bars. Word is also a tool commonly available to tactile graphics producers; if they already have Word, then they do not need to acquire the drawing functions separately. Apart from Word's recognized shortcomings as a Braille text application, its major flaw was the inability to export images to other applications. Word's save functions create a .doc file; to export the graphic to a common image format such as PNG, the user must select it, copy it, open another graphics program, paste the image into that application, and then use that application's export features.

CONCLUSION

We conducted a contextual inquiry within the tactile graphics production community. We administered an online questionnaire and conducted in-depth observation sessions. We found that tactile graphics specialists use a wide range of software and hardware to produce tactile graphics. Oftentimes, they used multiple software applications and hand tools to produce a single graphic. Their practices suggested that there was no packaged solution which enabled them to perform a combination of tasks like translating text to Braille, editing images for tactilization, and embedding Braille text within images. This shortcoming has left transcribers with a variety of, often incompatible, software and hardware that perform specialized functions.

Our evaluation showed that graphics applications are inadequate for tactile graphics producers. They do not support adding high-level Braille text to graphics. Each program's drawing tools require time and effort to learn, and some of their features are inappropriate for creating tactile graphics. Word's drawing environment, which tactile graphics producers use, had the best image output and simplest interface, but has minimal export capabilities and suffers from the several other deficiencies.

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