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Getting in Touch With Tactile Map Automated Production: Evaluating impact and areas for improvement

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Abstract

This study evaluated the impact the Tactile Maps Automated Production (TMAP) system has had on its blind and visually impaired (BVI) and Orientation and Mobility (O&M) users and obtained suggestions for improvement. A semi-structured interview was performed with six BVI and seven O&M TMAP users who had printed or ordered two or more TMAPs in the last year. The number of maps downloaded from the online TMAP generation platform was also reviewed for each participant. The most significant finding is that having access to TMAPs increased map usage for BVIs from less than 1 map a year to getting at least two maps from the order system, with those who had easy access to an embosser generating on average 18.33 TMAPs from the online system and saying they embossed 42 maps on average at home or work. O&Ms appreciated the quick, high-quality, and scaled map they could create and send home with their students, and they frequently used TMAPs with their braille reading students. To improve TMAPs, users requested that the following features be added: interactivity, greater customizability of TMAPs, viewing of transit stops, lower cost of the ordered TMAP, and nonvisual viewing of the digital TMAP on the online platform.

Keywords

Tactile, Map, Blind, Orientation and Mobility, Evaluation, Low Vision

Introduction

Maps are a critical part of everyday life (Longley et al.). While blind and visually impaired (BVI) travelers routinely use verbal directions from GPS applications, maps have been repeatedly shown to more effectively convey spatial knowledge to the user (Williams et al.; Papadopoulos, Koustriava, et al.). Siegel and White explain there are three types of spatial knowledge: route, landmark, and survey knowledge. Lack of spatial knowledge increases fear and anxiety around travel for BVIs, but maps for BVIs are difficult to obtain (Jacobson; Papadopoulos, Barouti, et al.).

Until recently BVI individuals have had almost no access to tactile maps (Butler et al.; Rowell and Ongar; Rowell and Ungar). There are two major problems with tactile maps: generating/making a usable tactile map, and viewing the tactile map (Butler et al.). Since the early 1800s, tactile maps have been custom made by sighted tactile graphic specialists and take hours to complete (Weimer; Amanuensis Braille; BANA and CBA). Tactile maps are normally created with a graphics embosser or swell paper machine with braille labels, and are often simplified with limited or abbreviated information (BANA and CBA; Brock et al.).

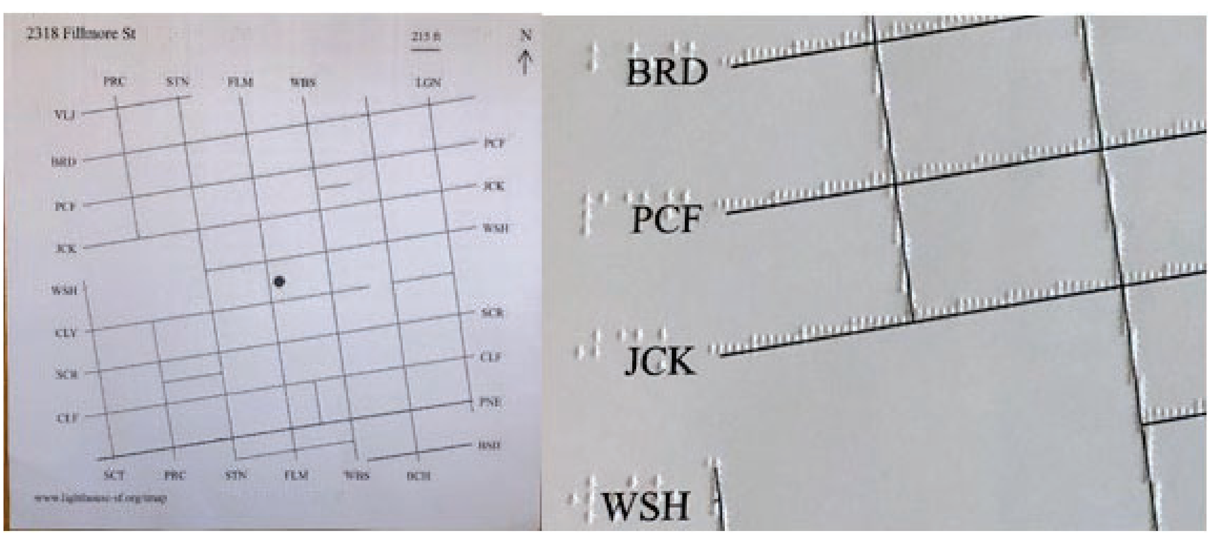

Fig. 1. Picture of Two TMAPs: One zoomed out and the other zoomed in.

To remove the need for an expensive transcriber to create a generic map of a neighborhood, the Tactile Map Automated Production system (TMAP) was developed by Joshua Miele at the Smith-Kettlewell Eye Research Institute (SKERI), and transferred to the MAD Lab at the San Francisco LightHouse for the Blind and Visually Impaired for production and future development in 2017 (Miele et al.; Lighthouse; *LightHouse for the Blind and Visually Impaired of San Francisco*). The TMAP system accepts an address from the user, and outputs a standardized SVG tactile map that can be embossed on a tactile embosser or swell paper machine. TMAP uses data from OpenStreetMap (OSM) (*OpenStreetMap*) and shows any combination of streets, walkways, and buildings. The view that is presented is often around five or six city blocks wide, depending where the address is located (see Fig. 1a). TMAPs standardizes many elements of the map, such as shortening street names to two or three letters (e.g., Jackson Street may be shortened to JCK, see Fig. 1b). Streets are represented with a solid line, walkways are represented by a dashed line, buildings are represented by a filled-in shape of the building on OSM, and a circle representing the address of the user is shown at the center of the map. A key for both the tactile features and the abbreviations is given as a second page with the map.

There are currently two methods for obtaining and viewing a tactile map: 1) The online Adaptations store at the LightHouse sells TMAPs both online and over the phone. These maps come with two zoom levels, one level that is zoomed in with buildings shown, and a second map that is zoomed out with no buildings shown. It often takes between 1-6 weeks to obtain a TMAP, depending on shipping preferences. 2) LightHouse has an online web application that individuals can use to generate, download, and emboss their own maps. This study evaluated the effect

TMAPs has had on both its BVI and orientation and mobility specialist early adopters and obtained suggestions for improvement.

Orientation and mobility specialists (O&Ms) teach BVI individuals "to utilize their remaining senses to determine their position within their environment and to negotiate safe movement from one place to another" (*Certified Orientation and Mobility Specialist (Coms®)*). O&Ms often teach tactile map literacy, and can use TMAPs in their lessons.

Study

The goal of this study was to find the impact TMAPs has had on its existing users, and how TMAPs can be improved. A mixed-method study was performed on existing TMAP users through both a coded semi structured interview, and an analysis of the online system usage logs. Although the questions were similar between BVIs and O&Ms, responses were very different. There were a total of 13 participants, 6 BVIs, and 7 O&Ms. All 25 TMAP users as of March 2020 from both the order system and online application with an email address, and who had ordered or downloaded 2 or more TMAPs, were contacted.

Table 1. BVI Participants.

Label	**Total number of y responses**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**
I am a Braille reader	6	y	y	y	y	y	y
See Light perception or less	6	y	y	y	y	y	y
Age to become Blind		4.5	0	0	0	0	0
Age		31	35	52	25	37	39
Gender		m	m	m	m	f	m
I use a cane	5	y	y	y	y	n	y
I use a dog	1	n	n	n	n	y	n
Location		U.S.	UK	U.S.	U.S.	U.S.	U.S.
Interviewed March 2020	6	y	y	y	y	y	y

Table 2. O&M Participants.

Label	Total number of y responses	P7	P8	P9	P10	P11
Age		34	29	48	55	64
Gender		Nonbinary	f	m	f	m
Years teaching O&M		10	6	3.5	22	6
I mostly teach Adults 18+	5	y	n	y	n	y
I mostly teach Children Birth-age 22	2	n	y	n	y	n
Location		U.S.	U.S.	U.S.	U.S.	U.S.
Interviewed March 2020		y	y	y	y	n
Interviewed Dec 2020	4	34	29	48	55	64

The hour-long interviews were held over video conference or telephone, and were recorded. Participants received $30 an hour, and IRB approval was given through SKERI. The recording was then transcribed using Otter.ai, then coding was performed on the transcript. Usage logs from the online TMAPs system from March 2019-March 2020 were obtained and compared with the responses in the interview on map usage.

Each transcript was coded utilizing an inductive thematic analysis (Braun and Clarke; Campbell et al.; Caulfield). There were 5 steps to the process: 1) The transcripts were coded for important statements, such as “I don’t use tactile graphics other than braille”; 2) Codes were grouped into labels that represented the general sentiment of all the codes, such as “TMAPs is the only tactile graphic I use”; 3) Labels were sorted into six categories (demographics, creation, map history, feature requests, usage, and problem; e.g., the label in step 2 would be placed in “usage”); 4) The number of responses for each label were counted and the sums were sorted for BVIs, O&Ms, and total; and 5) An analysis was performed on the data, which is presented below. In the analysis, “n” (for “no”) designates that the user did not have the code in their interview, it does not mean they disagreed with the statement, and since the codes and labels were developed inductively from a semi structured interview, not all participants talked about the exact same topics. There were 118 unique labels.

One researcher coded all thirteen interviews, and a second collaborator coded three randomly selected interviews, and intercoder reliability was obtained (Campbell et al.). This process involved both collaborators initially coding the three interviews individually, and comparing the codes for each interview. The final inter-coder reliability was 99.58%. To sort the codes into labels, one collaborator performed the initial label creation and categorization, and two other collaborators reviewed the list of labels, codes in each label, and reviewed the list of codes for each interview to check for missing codes in a label or to see if a new label should be added.

Results for BVI Users

Table 3. BVI Map History.

Past Usage	**Total number of y responses**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**
Got or produced less than one map a year before TMAPs	5	y	y	n	y	y	y
Obtained last TMAP less than a month ago	3	n	n	n	y	y	y
Use other tactile graphics than TMAPs	3	n	n	n	y	y	y
Obtained first TMAP before 2019	3	n	n	n	y	y	y
Have embosser at home	3	n	n	n	y	y	y

Table 4. BVI Generated TMAPs.

Generated TMAPs	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**
Obtained last TMAP less than a month ago	n	n	n	y	y	y
Number of Online Generated TMAPs	0	18	0	11	28	16
Number of TMAPs they said they embossed at Home or Work	0	0	0	18	84	24
Number of TMAPS they said they ordered from Lighthouse in the last year	2	0	2	0	0	0

Generated TMAPs	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**
Number of TMAPs they said they ordered from an external embossing center in the last year	0	2	0	0	0	0
Total Number of Said Obtained TMAPs in the last year	2	2	2	18	84	24

Table 5. BVI Usage of TMAPs.

Label	**Total number of y responses**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**
Use TMAPs to go on trips	6	y	y	y	y	y	y
I use TMAPs to understand layouts of streets and intersections	5	y	y	n	y	y	y
I use maps to build an understanding of a location	5	y	y	y	n	y	y

Table 6. BVI Identified Problems.

Label	**Total number of y responses**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**
TMAPs are too difficult to obtain without an embosser	6	y	y	y	y	y	y
TMAPs are not dynamic enough	4	y	n	y	y	y	n

Table 7. Feature Requests from BVIs.

Label	**Total number of y responses**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**
Want to view transit stops	5	n	y	y	y	y	y
Would like interactivity	5	y	y	y	y	y	n
I would like if clients or I could print TMAPs at home, because being able to emboss at home is critical	5	y	y	y	y	n	y
I would like a lower cost tactile only TMAP	4	y	n	y	y	n	y
Would like way to view map online non-visually	4	n	y	n	y	y	y

Results for O&M Users

Table 8. O&M Map History.

Label	Total number of y responses	P7	P8	P9	P10	P11	P12	P13
Used handmade maps / Swell paper before TMAPs	6	y	y	y	n	y	y	y
I use other tactile graphics than TMAPs	6	y	y	y	y	y	n	y
Students map reading level is beginner	5	y	y	y	y	n	n	y
I got/produced more than 7 maps a year before TMAPs	5	y	n	y	y	n	y	y
Obtained first TMAP before 2019	5	n	y	y	n	y	y	y
Obtained last TMAP between 1-6 months ago	4	n	y	n	n	y	y	y
Used last TMAP more than a month ago	4	n	n	n	y	y	y	y
Most students are not braille readers, or TMAPs are too advanced for their tactile diagramming skills	4	y	n	n	y	y	y	n
Students have found TMAPs to be helpful	4	n	n	y	n	y	y	y

Table 9. O&M TMAP Generation.

Generated TMAPs	P7	P8	P9	P10	P11	P12	P13
Number of Online Generated TMAPs	4	2	0	2	6	4	0
Number of TMAPS they said they produced in the last year	10	10	0	0	6	0	0
Number of TMAPS they said they ordered from LightHouse in the last year	0	0	2	3	0	5	6
Total number of said obtained TMAPs	10	10	2	3	6	5	6

Table 10. O&M TMAP Usage.

Label	Total number of y responses	P7	P8	P9	P10	P11	P12	P13
I use both the tactile and visual elements of TMAPs	7	y	y	y	y	y	y	y
I like multiple zoom levels	6	n	y	y	y	y	y	y

Label	Total number of y responses	P7	P8	P9	P10	P11	P12	P13
I use TMAPs to understand a Local area like my neighborhood	6	y	y	y	n	y	y	y
I use maps to build an understanding of a location	5	y	n	y	n	y	y	y
I use TMAPs to understand layouts of streets and intersections	5	y	n	y	y	y	n	y
I like how current tactile features are represented on the map	5	y	n	y	y	y	y	n
I like to see the buildings	5	n	y	y	y	y	y	n
I like TMAPs is customizable	5	y	y	n	n	y	y	y
I use TMAPs to understand Features around where I am going on a trip	4	n	n	y	n	y	y	y
TMAPs are Difficult to Understand	4	n	n	y	y	y	n	y
I like online interface	4	y	y	n	n	y	y	n
TMAPs give a good overview of an area	4	n	n	y	n	y	y	y

Table 11. O&M Problems Around TMAPs.

Label	Total number of y responses	P7	P8	P9	P10	P11	P12	P13
Paying for TMAPs is difficult	5	y	y	n	y	y	n	y
TMAPs are too difficult to obtain without an embosser	5	y	y	y	n	y	n	y
Buildings make the map difficult to understand	4	y	y	y	y	n	n	n
TMAPs are not dynamic enough	4	n	n	y	n	y	y	y

Table 12. O&M Feature Requests.

Label	Total number of y responses	P7	P8	P9	P10	P11	P12	P13
Would like interactivity	7	y	y	y	y	y	y	y
Would like to add and remove tactile features, like particular buildings	7	y	y	y	y	y	y	y

Label	Total number of y responses	P7	P8	P9	P10	P11	P12	P13
I would like a drag and drop interface to create custom tactile features, like building, dots, spiky bushes...	6	y	y	y	n	y	y	y
Would like ability to add or remove different interactive features	5	y	n	n	y	y	y	y
Would like to add multiple points on a map	5	n	y	y	n	y	y	y
Would like a refreshable tactile display that can show TMAPs	5	y	n	y	n	y	y	y
Would like ability to change the look/feel of each feature	5	y	y	n	y	y	n	y
Would like more ability to change the scale	5	y	n	y	y	n	y	y
I would like a lower cost tactile only TMAP	4	n	y	y	y	y	n	n
want maps of college campuses	4	y	y	n	y	n	n	y
Would like turn by turn directions	4	y	y	n	n	y	n	y
Would like natural features and off-grid features	4	y	y	y	n	n	n	y
Would like to change line thickness and height	4	n	y	n	y	y	n	y
Would like a super simple map	4	n	y	n	y	y	y	n
Want to have more training materials on TMAPs	4	y	y	n	n	n	y	y
I would like if clients or I could print TMAPs at home, because being able to emboss at home is critical	4	n	n	y	n	y	y	y

Discussion

The goal of this study was to find the impact of TMAPs on its existing users, and how TMAPs can improve.

BVI Users

The most important effect shown in this study was that five blind participants went from getting less than 1 map a year to getting at least two maps, with those who had an embosser generating on average 18.33 TMAPs in the last year from the online system and saying they embossed 42 maps on average at home or work. The online system usage data was obtained by counting the number of times a participant downloaded a map from the platform. The participants with an embosser mentioned that it sometimes takes multiple tries of changing the settings and downloading a map before it is correct, and once a map has been downloaded, it could have been embossed multiple times, which does not show up in this data. P5 mentioned they frequently generate maps for other people, so re-embossing the same map, or using another account to generate the map could explain their significantly higher estimate of 84 vs the 28 downloaded from the platform. This means that increasing availability and reducing the cost can completely transform map usage among blind individuals. The overwhelming sentiment was that despite the lower cost TMAP, it is still difficult to depend on the external TMAP production process, and having an embosser at home or work will increase map usage further.

The current usage of TMAPs is to view new locations while going on trips, including streets and intersections, but the biggest feature request was to add interactivity such as through Coughlan et al. One participant explained: “If I had a tactile map, I could have a picture in my head, and confidently go outside, on the streets, by myself”. Another participant said “I feel like I’m more empowered and I have more comfort level when I’m visiting a new place if I have a map”. On using GPS instead of a map, P5 explained: “When you read things in GPS as plain text, you may know kind of in theory, what streets are connected. But being able to get that bird’s eye view and understand exactly how things intersect and understand scale is really transformational.” Interactivity could allow a significant number of features to be shown, such as transit stops and building names, without increasing the tactile map complexity. With a digital aspect of the map, the utility of TMAPs could increase from just showing intersections and streets, to providing spatial guidance between two locations on the map. If GPS was also integrated, it could also show users their current position on the map as they are physically navigating. P1, who was also an O&M, provided one hesitation in describing their older BVI students: “Many clients don’t have a smartphone and don’t want one.” A possible solution P1 proposed was building a single purpose device that was extremely easy to use, without the complexity or negative experiences older users may have around a smartphone. Adding utility may increase the amount users are willing to pay for a map, but enabling users to view TMAPs before sending the TMAP to an embossing center may also reduce the map production cost.

The researchers interviewed the MAD Lab about their experiences with TMAPs, and the most expensive part of TMAP production is positioning the map to optimize space and minimize complexity. Although much of the TMAPs system is automated, positioning the frame and selecting features still requires a small amount of time from the MAD Lab staff. Every BVI user who had used the online system requested a method to digitally view the TMAP before printing. Having an online auditory view, such as Biggs et al., or the digital tactile display described in Biggs, would enable blind users to view the map on their computer or smartphone before ordering or printing the map. If users could position their map independently before ordering, it may help reduce the time, and hence the cost, of producing a TMAP.

One theme that was very clear from the responses is that having a map is not a replacement for the turn-by-turn directions provided by a GPS, instead, the directions from the GPS are used to supplement data from the map. This “picture” and “layout” participants have in their head after viewing a TMAP may be the survey knowledge from Siegel and White. With the anxiety and fear blind users often face when walking outside, having this extra level of spatial knowledge may facilitate more independent travel, increase positive emotions around travel, and increase community participation, as BVIs may be more willing to leave their house (Williams et al.; Jacobson).

O&M Users

O&M users utilized TMAPs as just one tool in their toolbox. The advantage that it had for them was quick generation of maps they didn't need a transcriber for. P8 described that "before TMAPs I would just use home-grown maps, lots of time spent with puff paint, Wheatley kit, the tactile drawing kit, and Wikki Stix". The main difficulty the O&Ms had was not being able to customize it for the extremely basic tactile diagram reading skills of their students. P10 admitted "we stopped using it [TMAPs] because his [their student's] tactile diagramming skills just weren't fine enough". Intersections were also very important to show with the TMAP: "We used TMAPs to figure out when intersections were coming up and the layout of intersections, because that information was not conveyed in GPS". P13 explained: "TMAPs is the first step in spatial awareness and orientation". The feature requests mostly focused around customizing the features so these students could have a map that was less complicated and easier to read. This could be done through an online map editing interface, similar to geojson.io or a paint tool (*geojson.io*). In general, TMAPs was very good at showing intersections and an overview of neighborhoods, and now O&Ms would like a more advanced and customizable mapping tool.

One question the researchers had in undertaking this study concerned the use of TMAPs with low vision students. P1 (the blind O&M) and P7 didn't think their low vision students would find TMAPs useful because of its minimal detail and the use of braille labels. P8, who worked with children, said they did use TMAPs with one low vision student: "My student who is unable to read braille, because she's got quite a lot of vision, she is able to see the map and is able to understand just like general layout of which street is which and where her destinations are… I find she pays more attention to the map when she has her hands on it." P13 also explained: "A lot of braille readers are low vision and like the high contrast". More research needs to be done on low vision users directly to make TMAPs something they would find useful.

Conclusions

The TMAP project has made a significant impact on map usage for its blind users, and has been a useful tool for its O&M users. Now that TMAPs has increased tactile map availability, 11 of the 13 participants wanted to see those efforts continued through more financial support and lower cost TMAPs. 12 of the 13 participants wanted to see TMAPs become interactive and expand the level of accessibility for non-braille readers and add detail on the map without increasing complexity. For BVI users, increasing the utility of TMAPs and allowing online viewing and creation of TMAPs should make maps easier to obtain. Allowing O&Ms to completely customize the map through an online visual editor should encourage O&Ms to use TMAPs more in their lessons. Ideally, there will be a higher resolution and portable digital tactile display that can show TMAPs, or portable virtual reality gloves that can communicate details at sufficiently high (e.g., 1 mm) resolution, but the technology needed for these has a way to go before this will be possible (*Size and Spacing of Braille Characters*; Durham; *HaptX | Haptic Gloves for Vr Training, Simulation, and Design*). TMAPs has enabled BVIs and O&Ms to obtain a relatively inexpensive tactile map, and these early adopters of the system want to see TMAPs continue providing less expensive, interactive, and more customizable maps.

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