Six-Tipped Ergonomic Braille Stylus

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Abstract

Braille literacy is an essential component of life for those with visual impairments. One challenge in cultivating Braille literacy is improving the process of writing Braille, a highly skilled task.The traditional method of using a stylus and slate (see Fig 1) is cheap and portable, and it is the method first taught to students. However, this method creates hand strain and fatigue and is not time efficient due to the stylus design and writing method. Hand strain is due to the thin, small nature of the stylus, making grip pressure high. Hand fatigue is the result of repetitively indenting card stock paper to create individual Braille dots. The process is not time efficient since the user must stab up to 6 dots within each ”Braille cell” to create indented bumps on the back of the paper. The dots of the cell comprise a 2x3 matrix, and varying combinations of these dots correlate to different Braille characters. To ensure that inter-dot spacing aligns with the 2x3 matrix, the writer uses the edges of each slate cell to guide dot placement. Thus, most of the writing time is spent in creating aligned spacing and stabbing up to 6 bumps for each individual character. To reduce both this time and the hand strain/fatigue, my team collaborated with a legally blind need-knower to design a novel, affordable, and mechanically altered 6-tipped rectangular stylus. Each tip of the stylus is correlated with a button. To punch out a character, the user would keep the stylus stationary, pressing down on each button necessary for their desired character. This stylus is designed to be used either with or without a slate since the alignment of the tips form a 2x3 matrix (eliminating the need for a dot spacing guide), and the user can slide their finger along the edge of the stylus to punch an adjacent character. When comparing the final product design to the single-tipped stylus/slate model, both are fully mechanical and require low material costs, and the 6-tipped stylus enhances portability by eliminating the need for a slate- the key benefits of the single-tipped stylus model are retained. The report discusses data collection, analysis, the proposed design, and test methods.

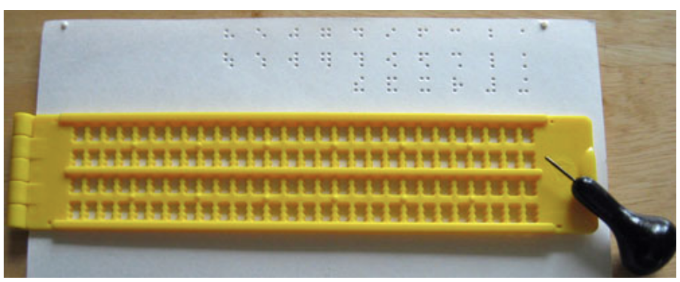

Fig. 1. Image of traditional stylus and slate

I. Introduction

According to the Community Eye Health Journal, about 36 million people worldwide are afflicted with blindness (defined as less than 3/60 to no light perception) [1]. Given historical trends, the Vision Loss Expert Group projects the blind population to increase to about 115 million by 2050. For those with visual impairments, Braille literacy is a very useful skill to receive and communicate information via tactile senses [2]. According to a 2009 fact sheet produced by the National Federation of the Blind, only 10% of legally blind Americans possess Braille literacy. Braille literacy is important for employment and education, factors essential in socioeconomically uplifting those who are visually impaired.

A. Background

One aspect of Braille literacy is writing Braille mechanically, an activity which poses challenges for both visually-impaired and fully-sighted people. Even for fully-sighted people, writing Braille is more difficult and time-consuming than writing characters with a pencil; it requires indenting card stock paper with a stylus, and creating evenly spaced dots within a cell. Since writing Braille is a highly skilled task, people with visual impairments use assistive devices to help writing.

According to the Braille Authority of North America (BANA), “knowledgeable professionals in the field have determined that using a slate and stylus is an essential skill that should be mastered by teachers of blind children and adults to enable them to competently teach this skill to their students”[3]. The BANA position statement also discusses how using a slate/stylus is more affordable/accessible than electronic alternatives or typewriters. Writing Braille mechanically is the equivalent of sighted people learning to write on paper with a pencil; mechanical writing is a part of literacy, and any technology is just a supplement to this essential skill. However, for those with either limited hand strength or a need for time-efficient writing (such as note taking during a fast-paced presentation), there ought to be an assistive device that augments mechanical Braille writing while retaining affordability.

The American Printing House for the Blind provides the most updated, comprehensive resources and tools for Braille literacy[4]. Their official handbook on Braille writing tools only includes two categories of assistive Braille writing devices: one category is the traditional slate/stylus setup and the other category is mechanical ”braillewriters”. ”Braillewriters” are essentially typewriters that create Braille bump dots- the most commonly used braillewriters are the Perkins braillewriter and the Mountbatten braillewriter. The former is entirely mechanical and costs upwards of $800. The latter combines an electronic computer and mechanical Braille writing and costs upwards of $2000. The Mountbatten is also good for those with limited hand strength. The American Printing House does not have any other suggestions that are more advanced than a traditional slate/stylus, but less advanced/expensive than a Braillewriter. There are also no suggestions that retain the portability of a slate/stylus. To address this gap, our group aimed to design a mechanical Braille-writing utensil that retains portability and affordability while reducing hand strain, hand fatigue, and writing time.

B. Overview

In Section II we present data from an interview with someone who is visually impaired. Our data provided insights regarding the gaps and challenges faced by those with visual impairments. We will also explore methods we used to integrate our insights into a novel design solution. In Section III, we present our proposed device, the augmented 6-tipped Braille stylus. This section will explore our prototype design, and compare this with the ideal/intended device design. This section will also discuss methods we propose to test our stylus and evaluate how effectively it performs its intended functions of improving efficiency, decreasing hand strain, and improving readability.

Prompt/Theme	**Interview statement**	**Interpreted need**
Organization	“I like writing readable lists and making labels.” ”Writing in Braille is difficult because the cells are so small and 6 dots needs to fit evenly spaced in the cell”	Requires readable writing for organizational needs. Could benefit from a device that ensures even spacing.
Hobbies	”Writing poetry by hand is a past-time, but it’s time consuming and straining with Braille slates and styluses”	Values writing by hand but needs to save time and be efficient.

TABLE I
KEY INTERVIEW FINDINGS

II. Interview case study

We conducted a needs-identifying interview with someone who is diagnosed with retinitis pigmentosa, a condition that breaks down retinal cells over time. This condition contributes to loss of night vision, and decreased peripheral vision. This interviewee experienced tunnel vision severe enough to constitute legal blindness, and they shared their insights about their daily routine and disability-related needs. Although dexterity does not intuitively seem related to visual impairment, having a visual impairment necessitates using dexterity and tactile senses to navigate their surroundings. The interviewee specifically spoke about their troubles with writing Braille. As seen in the table, they prefer writing by hand to enhance Braille literacy, fulfill creative expression needs, and make short lists/item labels when organizing their living space.

They shared that when writing manually with an ordinary stylus and slate, readability is an issue when writing quickly, since having a visual impairment makes it difficult to take note of even spacing between dots in the cell. Carefully indenting the paper along the sides of the slate cells can ensure readability, but this is time consuming and not foolproof. The interviewee provided a live demonstration of writing Braille with a regular one-tipped stylus and slate. The process was time consuming, and the interviewee showed how it was easy to lose one's place when writing Braille the traditional way.

III. Proposed Device & Test Methods

A. *Proposed Device*

The device we are proposing is a 6 tipped stylus. The tips will be arranged in a rectangular 2X3 matrix, and the stylus size will be scaled down so that all the tips can fit in one Braille cell (defined in Abstract). This ensures that as long as the writer keeps this 6-tipped stylus stationary within their slate cell, all of their indentations will be perfectly spaced with respect to the other indentations within the cell, improving readability. The stylus will be controlled by 6 elevated, push-able buttons at the top, with each button correlating to each tip. Pushing down on a button causes the tip to extend down, indenting the card stock paper. For each cell, different buttons will be pressed by the writer depending which combination of points in the cell they need to indent to represent their desired alphanumeric character or punctuation.

Pressing down these buttons requires less hand strain than using a traditional stylus to indent the paper with the full force of the wrist/hand. Users can alternate which fingers they use to press the buttons, decreasing fatigue on any singular finger. This stylus will also be wider than a traditional 1-tipped stylus, making grip easier. According to Professor Doreen Stiskal, a hand grip researcher from Seton Hall University's kinesiology department, a wider pen reduces gripping pressure [5]. Since pressure is equivalent to force divided by surface area, increasing the pen's area reduces pressure.

Each time the writer presses a spring loaded button to create an indentation in the paper, the tip will remain in contact with the paper, remaining in its extended position until the user clicks the button affiliated with that tip, retracting/disengaging the tip.

We designed a prototype that is scaled larger than the intended design. Figures 2 and 3 display the CAD models for the prototype (more images provided in Appendix). The top piece is the trigger/button housing, and the individual pen barrels serve as the punchers/stylus tips. The end piece represents the stylus housing. We aim to design a more comprehensive, scaled down version of the stylus by optimizing our Solidworks design and using a compatible, precise 3D printer to print our buttons, tips, and casing.

With the current prototype, the user can individually retract all the tips and guide their finger along the edge of the stylus to move the stylus by one cell-length. However, this edge-guiding method does not guarantee that the adjacent character will be exactly in line with the previous character, and retracting the tips individually consumes extra time. Thus, after the user punches out a desired character, we want to optimize the pen to automatically retract all tips and horizontally and linearly slide by one cell-length. We will also experiment with various retraction mechanisms by studying the retraction mechanisms of multicolored ballpoint pens, and seeing what adjustments ought to be made to coordinate simultaneous tip retraction. By coupling the simultaneous retraction mechanism with a sliding mechanism, this could save time and ensure greater precision. Although this sliding mechanism would not be necessary if the user wants to use this stylus with a slate (which easily helps guide the user to the next cell), making this stylus usable without a slate would aid portability and convenience.

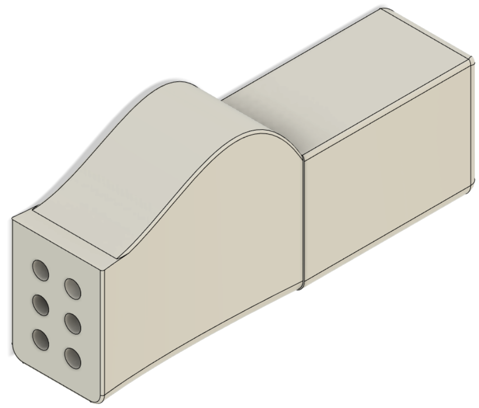

Fig. 2. Assembled Version of CAD Model

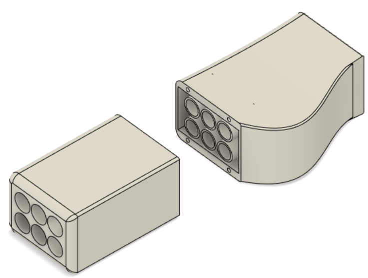

Fig. 3. Disassembled Version of CAD Model

B. Test Methods

Once the pen is scaled down, we will test our hypothesis by comparing hand fatigue/time efficiency between indenting with our augmented 6-tipped stylus and indenting with a traditional standardized 1-tip stylus and slate. We can run timed tests on writing the same Braille characters and compare which stylus allows for a quicker writing time. Hand fatigue/strain is not as quantifiable, so we will use a personalized sliding scale for pain to loosely evaluate this factor. We will also evaluate for readability by comparing evenness of spacing between the characters written by the 6-tipped and 1-tip styluses. It would be interesting to run these tests on a larger number of human subjects, so if we got the chance to do that, we would have to submit a protocol for review through the Internal Review Board for the Protection of Human Subjects. Our research team has completed the CITI training for either Group 1 or Group 2 as of 4/18/23.

IV. Intellectual Merit

The idea of a 6-tipped stylus is a novel idea unexplored in Braille-related technology. As described in the background, there is a major gap between the traditional stylus/slate model and very advanced, expensive Braille-writing typewriters or electronic software. Augmenting the traditional slate/stylus model is an affordable, accessible solution to this gap, and addresses the problems of hand strain, fatigue, and time-inefficiency. However, there are many gaps in our design. We still need to scale the stylus down to a size that aligns with the slate cell, and this was not possible given the 3D printers we used. When scaling down, it would be useful to reduce the scale of the tip alignment while retaining the same size for the ergonomic handle and the buttons pressed by the user. If our hypothesis that this stylus would improve writing speed and hand fatigue/strain is true, this would be encouraging for those who are visually impaired. If this hypothesis fails, then a traditional stylus and slate would be a better option. The next steps of this study could involve addressing these fundamental gaps, and also developing a mechanism to slide from one cell to another, akin to how a typewriter mechanically shifts and locks into a new position for each character. Since losing one's place is easy in the Braille writing process, allowing the pen to simultaneously retract and immediately lock into the next cell may be even more preferable for avid Braille writers.

V. Broader Impact

This augmented 6-tipped stylus would be a relatively affordable, reproducible Braille writing technological innovation that ideally reduces hand strain, improves time efficiency, and enhances readability. Even though Braille typewriters and various software tools make Braille writing more convenient and less strenuous for those with visual impairments, many of these technological advancements are not accessible or affordable. Additionally, writing Braille manually is an essential part of Braille literacy, so the stylus/slate will remain timeless. It would be a good idea to make this an open source design since it is still in its developmental stages, and more experienced industry engineers can address any logistical gaps that we are unable to account for.

References

[1] e. a. Ackland, Peter, "World blindness and visual impairment: Despite many successes, the problem is growing," *Community Eye Health*, 2017.

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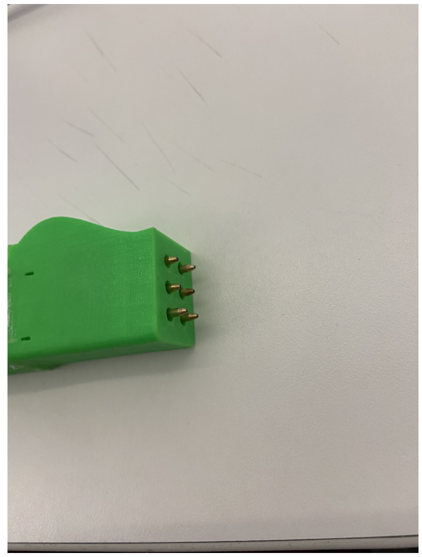
[4] "Tools for writing for children who are blind or low vision," https://familyconnect.org/assistive-technology/tools-for-writing/, 2021.

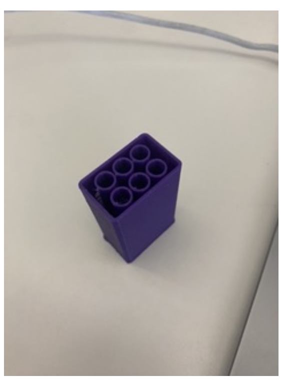
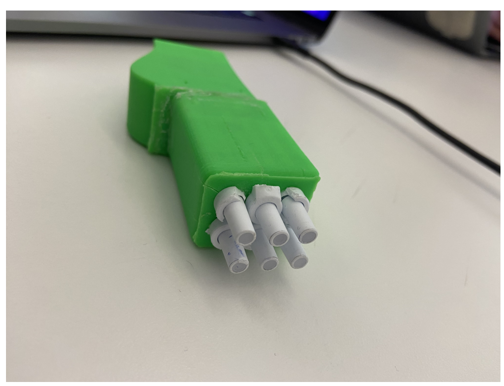
[5] "What's up with the big pens? ergonomics gets a grip on writing instruments." https://www.mcall.com/2002/11/19/whats-up-with-the-big-pens-ergonomics-gets-a-grip-on-writing-instruments/, 2021.

APPENDIX A
INVESTIGATIONAL DEVICE DETAILS

A. *Mechanism*

The final design consists of the same 6 tipped stylus structure mentioned above. Each stylus retracts and clicks into place, heavily inspired by a mechanical pencil's tip. Each stylus has a spring attached to the end that is caught with divots along the stylus stem. Each stylus is then inserted into one of the tubes in the pen casing. Within the base of the tube, is another circular divot which will catch the spring and pen. The spring will resist any force applied to the stylus from behind, which is what will let it retract when the force is let go.

The top of the pencil consists of a two by three button-like grid, each corresponding to a stylus pen that protrudes from the bottom. Each button held together by press fits along the top of the pencil. These buttons were dissected from your traditional mechanical pencil and broken into its smallest components. Within the back of most mechanical pencils are a rotating set of teeth that catches one another every time you press upon a resisting object within its casing. The object being the stylus, which is giving resistance from do to the spring. Once the button is pressed again, the teeth rotate to unlatch and move back into its default state, simultaneously releasing the force applied on the pen and spring, retracting the tip back into the pen.

B. Aesthetic and Ergonomics

The casing design was manufactured through 3D printing in two separate parts. The curve was added onto the external part of the design to ensure a better grip on the pencil, which is an intentional contrast to the single tip stylus and slate, which is skinny in frame and harder to grip. The design also caves inwards from sides of the pen, for those who choose a traditional grip.

C. Improvements

After final prototyping, there are many approaches my team can make to improve the design. A requested improvement by multiple people after showcasing our product is a way to retract all the pens at once. The idea is instead of clicking each button, you can press a button on the side to retract the buttons that were pressed automatically. This will provide a more efficient way of punching the braille into the indents, as the subject with impairment does not have to click what seems to be like double the amount of times to create a character in Braille. Final implementations to the prototype also consist of creating a stronger stylus material (such as the industrial grade steel used in a traditional one-tipped stylus), which can pierce the indents with ease as opposed to mechanical ink tips. As well as, improving material assembly with implemented interference fits with the case itself, as supposed to be held together by press fit prongs.