NavTap and BrailleTap: Non-Visual Texting Interfaces

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ABSTRACT

Mobile devices play an important role on modern society. Their functionalities go beyond the basic communication, gathering a large set of productivity and leisure applications. The interaction with these devices is highly visually demanding disabling blind users to achieve control. Particularly, text-entry, a task that is transversal to several mobile applications, is difficult to accomplish as it relies on visual feedback both from the keypad and screen. Although there are specialized solutions to overcome this problem, those are ineffective. Hardware solutions are unsuitable to a mobile context and software approaches are adaptations that remain ineffective, hard to learn and error prone. We present two new text input methods that dismiss memorizing by altering the meaning of the mobile device keypad while exploring the user's capabilities. User studies validated the proposed approach which surpassed the most commonly used approaches and gathered overall user approval.

KEYWORDS

Mobile accessibility, blind, text-entry, Braille, evaluation

BACKGROUND

Mobile phones have become an important part of our daily life. These are no longer mere communication devices; yet, they now allow us to store and manage important data, like contacts, personal notes or scheduled tasks. One task that is transversal to the majority of applications in a cell phone is text input. However, this task is visually demanding both considering the keypad layout and the screen output. This fact excludes blind users as mobile phones are misaligned with these users' needs and capabilities, and although many visually impaired users can use a mobile phone for simple tasks (like making or receiving a call), only a small group can go further.
Text input on mobile phones is commonly achieved through a multi tap system where groups of 3 or 4 letters are assigned to each key; pressing consecutively the same key allows the user to go through all the letters available on that key (Photo 1).

Insert Photo 1 Here: Regular mobile phone keypad

Other text-entry methods were developed to improve text entry, like Thumbscript (1) or MessagEase (2), but like the multi tap system, have a high visual and cognitive load. Existing text-entry approaches rely on the ability to see the sentence evolution and the keypad. With experience, a user can be able to achieve some success without looking to the keypad but this is only achieved after years of successful and feedback-rich usage and even an expert requires occasional confirmation. Although multi tap system is a very practical method for most of the users, those with visual impairments face several difficulties to use it. No information about letter displacement on the keypad is available and no feedback is offered about the entry evolution. Screen readers partially deal with this problem by reading the information on the screen. However, the feedback offered is restricted to the output as no information is obtained on letter displacement. This approach forces the user to try to find the desired letter committing several errors in the process, possibly leading to situations where the user simply quits trying. Special mobile devices were developed to overcome the difficulties arising from visual impairments. As examples are the Braillino or the Alva Mobile Phone Organizer, among many others very similar between each other. These devices, which typically work as a Personal Digital Assistant (PDA), use a Braille keyboard for text input and a Braille screen for output information, and provide functionalities like the ones provided in regular mobile phones. Yet, they all share the same flaws: their cost is prohibitive and they are not as portable as a mobile phone is, being too big and heavy (Photo 2).

Insert Photo 2 Here: Alva Mobile Phone Organizer

STATEMENT OF THE PROBLEM

It is urgent to find a solution that approaches blind users and mobile devices. We study regular mobile devices and how can them be used by a blind user, relying on voice feedback to replace the information on the screen and featuring text-entry methods that eliminate the cognitive load on the keypad and explore the users (over)-developed capabilities.

DESIGN AND DEVELOPMENT

To cope with the text-entry problem by users with visual disabilities, we present two new text-entry methods: NavTap and BrailleTap. Both methods rely on a set of considerations gathered after analysis of the users' needs and capabilities. The main obstacle for a blind user to operate a regular mobile device is the need to memorize the position of each letter. To circumvent the lack of visual feedback, both output and input information must be offered through available channels. It is important to notice that possible communication channels, like tact or audition, are over-developed and the users are likely to perform better than a full capable user if the interaction is based on those senses. By adapting the interaction processes we minimize stress scenarios and encourage learning.

<u>NavTap</u>

The NavTap text-entry method allows the user to navigate through the alphabet using the mobile phone keypad. The alphabet was divided in five lines, each starting with a different vowel as these are easy to remember. Using the mark on key '5' we can map a cursor on the keypad using the keys '2', '4', '6' and '8' (Photo 1). Keys '4' and '6' allow the user to navigate horizontally through the letters while keys '2' and '8' allow the user to jump between the vowels, turning them into key points in the alphabet. Both navigations (vertical and horizontal) are cyclical, which means that the user can go, for instance, from the letter 'z' to the letter 'a', and from the vowel 'u' to 'a' (Photo 3). Key '5' enters a space or other special characters and key '7' erases the last character entered. This method drastically reduces memorizing requirements, therefore reducing the cognitive load. In a worst case scenario, where the user does not have a good alphabet mental mapping, he can simply navigate straight forward until he hears the desired letter. There are no wrong buttons, just shorter paths. Blind users can rely on audio feedback before accepting any letter, increasing the text-entry task success and the motivation to improve writing skills.

Insert Photo 3 Here: NavTap navigation scenarios to the letter ‘t’

BrailleTap

BrailleTap focuses on a common knowledge to many blind users: the Braille Alphabet. Again, transforming the keypad functionalities is the basis of this new text-entry method. In the Braille alphabet, letters are formed by groups of 6 dots in a 3x2 cell (Photo 4). Considering the keypad of a mobile phone (Photo 1) we can map that cell on keys ‘2’, ‘3’, ‘5’, ‘6’, ‘8’ and ‘9’. Each press on these keys fills or blanks the respective dot. Key ‘4’ allows the user to enter the letter or, if all dots are blank, enter a space. For example, to enter the letter ‘b’, the user has to press keys ‘2’ and ‘5’ followed by key ‘4’. Finally, key ‘7’ erases the last character entered. Although capitalized letters are not considered in these studies it would be possible to augment the functionality as some keys still remain available.
This method focuses on the user and replaces the non-memorisable keypad layout with a particular common knowledge within this user group.

Insert Photo 4 Here: Letters ‘a’, ‘b’, ‘q’ and ‘r’ in the Braille alphabet
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RESULTS

To validate our approach, we performed trials with the target population (Photo 5). The evaluation group was composed by three groups of five users with no previous experience in mobile text-entry. This guaranteed that all users were at the same starting point in the beginning of the evaluation. The trials were performed in a formation center for blind users, in a controlled and quiet environment. Each group of users was assigned to a specific input method: MultiTap (traditionally used), NavTap and BrailleTap. All of them featured voice feedback. Each text-entry method test lasted for three sessions (three days with a day in between) in which users performed a set of tasks consisting of writing specific sentences (different between sessions). The first session had a training period in the appropriate text-entry method. Data was collected from these tests in three ways: (a) inquiries before and after the tests that allowed us to know the users’ habits and opinions about the system; (b) through observation, taking notes of all users’ comments; (c) and finally through log files that recorded all the users’ actions during the tests.

Insert Photo 5 Here: Blind user testing the system

The first relevant result retrieved from the undertaken evaluation was the time required by the users to get acquaintance with the methods. Although we determine the same training time (20 minutes), with the two proposed approaches the users were prepared for the test a few minutes (about 5) after getting instructed. Overall, after the twenty minutes training session the users argued to be ready and prepared to write the test sentences. However, even after the training session, the number of errors committed using the traditional MultiTap method is very high (Graph 1). The users did not completely memorize the keypad layout and were recursively obligated to guess a key and with the audio feedback try to recover the error and find the desired letter. Graph 2 presents the Minimum String Distance Error Rate (3) for all the three sessions and methods, where we can state that the final result of the sentence is not as erroneous as the process itself. This is easily explained with the “trial and error” approach the users are obligated to follow using the traditional method. The insertion is corrected but after several mistakes. Considering performance, the Braille-based method is clearly superior and achieves a 3.50 Words Per Minute (WPM) (3) performance (Graph 3)**.** Although NavTap performs better than MultiTap and shows improvement across sessions, it is important to notice that this method was tested with a defined timeout for letter acceptance in contrary to the other two methods where the *space* key (BrailleTap) and any other key (MultiTap) function as *timeout-killers*. NavTap method is presented as an easy method in a first approach and allows performance improvement as the users get used to navigate through shorter paths and need less Keystrokes per Character (KSPC) (Graph 4). Overall, it is important to highlight that all the users were interested in continue using the proposed methods (none was able to write text within their mobile phones before the trials).

Insert Graph 1 Here: Number of errors
Insert Graph 2 Here: Minimum String Distance Error Rate
Insert Graph 3 Here: Words per Minute
Insert Graph 4 Here: Keystrokes per Character

DISCUSSION

Text-entry interfaces that consider the users’ needs and capabilities are likely to ease the first contact and allow performance improvement. Considering text input for blind users, results showed that, if the cognitive load is removed and the users are presented with easier and user-centered interfaces, success is achieved as the first contact has a small error rate and the learning curve is accentuated. It is therefore possible to offer blind users with effective interfaces that require no extra hardware and permit usage by a wide set of users even those with no previous acquaintance with mobile devices.

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GRAPHICS PAGE

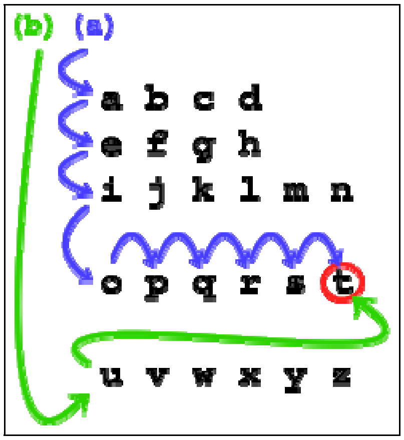
Photo 1: Regular mobile phone keypad

Alternative Text Description for Photo 1: Regular mobile phone keypad
Image shows the keypad of a common mobile phone and the letter displacement over the keys.

Photo 2: Alva Mobile Phone Organizer

Alternative Text Description for Photo 2: Alva Mobile Phone Organizer
Image shows a visually impaired user holding and using the Alva Mobile Phone Organizer with both hands.

Photo 3: NavTap navigation scenarios to the letter ‘t’



Alternative Text Description for Photo 3: NavTap navigation scenarios to the letter ‘t’
Image shows the alphabet splitted in five lines, each starting with a different vowel, illustrating two scenarios of navigation to the letter ‘t’ using the NavTap method. In scenario ‘a’, the user only uses two directions to navigate (down and right) and needs 9 keystrokes to reach the letter ‘t’. He goes down to ‘a’, ‘e’, ‘i’ and ‘o’ and then right to ‘p’, ‘q’, ‘r’, ‘s’ and finally ‘t’. In scenario ‘b’ the user uses four directions (up, down, left and right) and needs only 2 keystrokes: up to ‘u’ and left to ‘t’.

Photo 4: Letters ‘a’, ‘b’, ‘q’ and ‘r’ in the Braille alphabet
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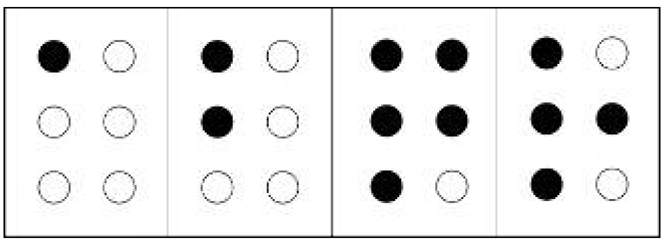
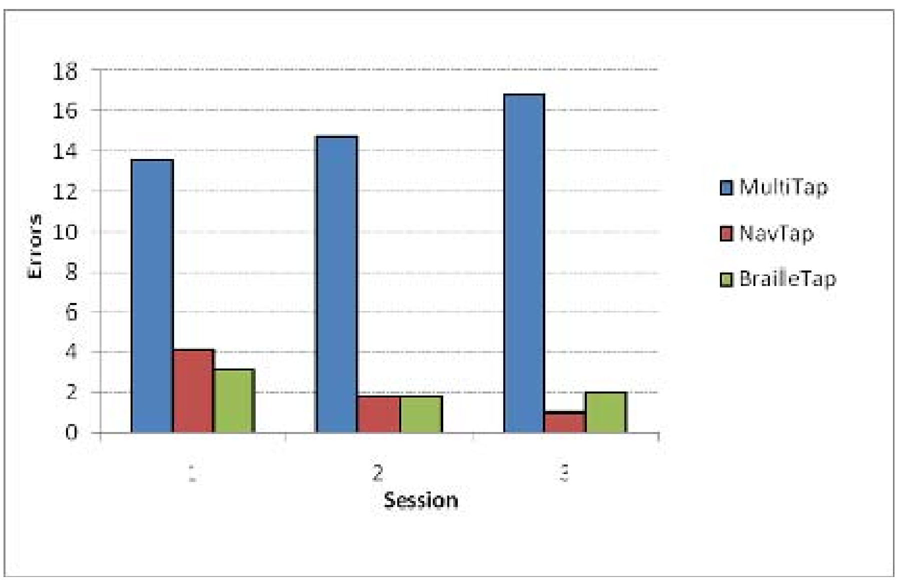


Alternative Text Description for Photo 4: Letters ‘a’, ‘b’, ‘q’ and ‘r’ in the Braille alphabet
Image shows the letters ‘a’, ‘b’, ‘q’ and ‘r’ represented in the Braille alphabet. Each letter is represented in a cell with 6 dots, in 3 lines and 2 columns.

Photo 5: Blind user testing the system

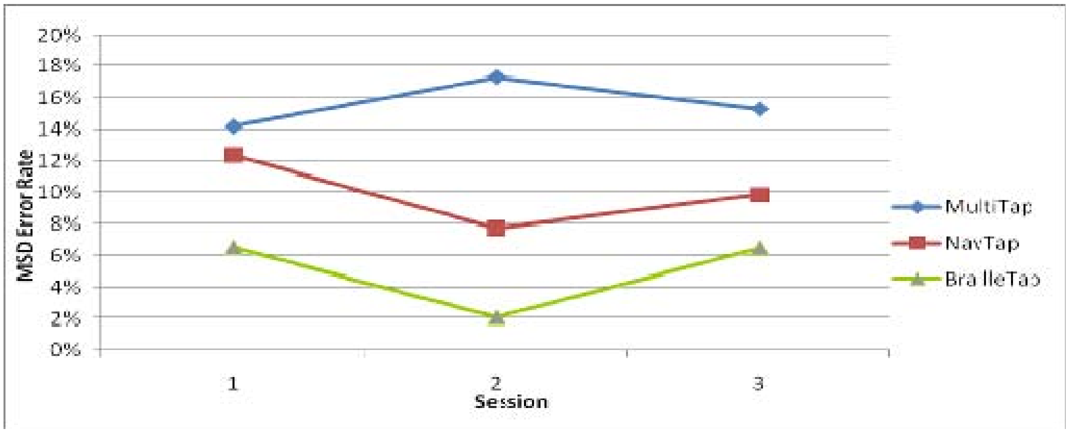
Alternative Text Description for Photo 5: Blind user testing the system
Image shows a blind user during a trial session. The user is holding the keypad in one hand and feeling the keys with the other hand fingertips.

Graph 1: Number of errors



Alternative Text Description for Graph 2: Number of errors
This graph presents mean number of errors obtained in each of the three sessions with the three different methods (traditionally used MultiTap and proposed NavTap and BrailleTap). In the first session, Multitap registered a mean value of 13.6 errors per sentence while NavTap registered 4.13 and BrailleTap 3.20. In the following sessions MultiTap still performed worst (14.80 and 16.88) than BrailleTap (1.80 and 2) and NavTap (1.80 and 1).

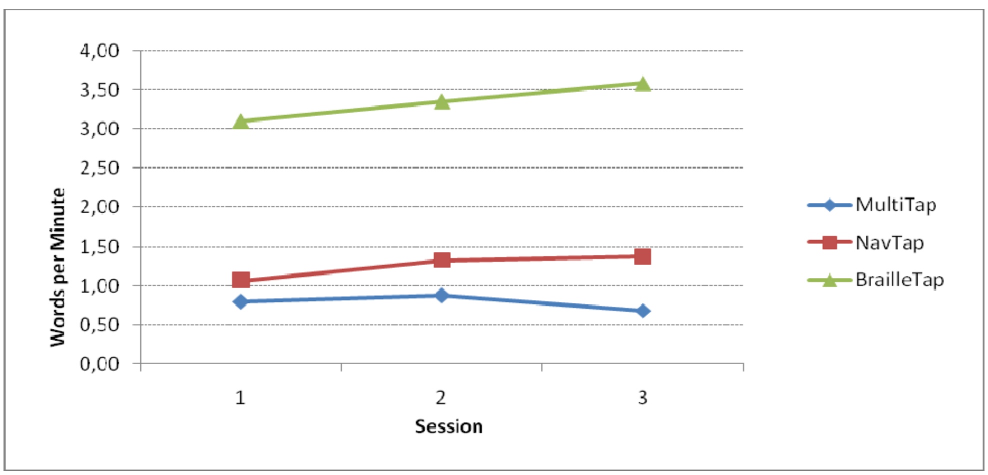
Graph 2: Minimum String Distance Error Rate



Alternative Text Description for Graph 1: Minimum String Distance Error Rate

Graph 2 depicts the minimum string distance error rate. It presents the three lines associated with each method across the three sessions. BrailleTap error rates are the lowest (6.55%, 2.07%, 6.55%), NavTap had a peak error rate in the first session (12.37%, 7.75%, 9.87%) while MultiTap had the worst results (14.19%, 17.33%, 15.28%).

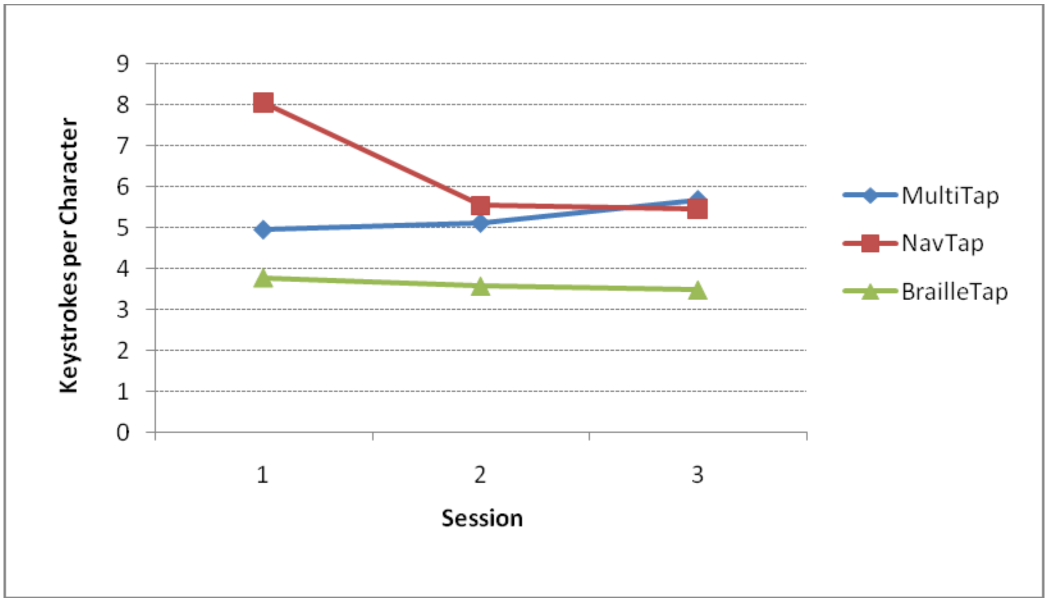
Graph 3: Words per Minute



Alternative Text Description for Graph 3: Words per Minute

Graph 3 depicts the mean words per minute ratio for each method in each session. A set of three lines present an evolution in the BrailleTap (3.11, 3.36, 3.6) and NavTap (1.07, 1.32, 1.37) methods while a decrease in performance in MultiTap (0.80, 0.88, 0.68) method.

Graph 4: Keystrokes per Character



Alternative Text Description for Graph 4: Keystrokes per Character

Graph 4 presents the evolution on the number of Keystrokes per Character across the three sessions with the three methods, one line for each method. NavTap presents the highest initial value but also the highest improvement (8.07, 5.55, 5.47) while BrailleTap presented slight improvements (3.78, 3.57, 3.48) and MultiTap (4.96, 5.12, 5.68) decreased performance.