Assessing Braille Input Efficiency on Mobile Devices

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Abstract. Our team has conducted a research on how today's Braille input methods suit the needs of blind smartphone users. Hungarian blind volunteers (all active Braille users) were invited to participate. The research consisted of a survey on the participants' relation to Braille and a series of input tests based on short Hungarian and multilingual texts both in grade 1 and 2 Braille using different devices and methods. Results showed that experienced Braille users can achieve remarkably high speeds and accuracy and that the use of contracted Braille further increases input efficiency. This paper also discusses the characteristics of typos occuring and their manual or automated correction during Braille input on mobile devices. Adding adequate automated correction mechanisms optimized for Braille typos may further increase the input speed nearing or even surpassing the speed of sighted people using ordinary on-screen input methods.

Keywords: Assessment and profiling · Accessibility · Blindness · Assistive technology · Braille · HCI and Non-classical interfaces · eLiteracy · Usability and Ergonomics · Mobility · Input methods · Efficiency

1 Introduction

In Hungary, assistive technology based on speech synthesis has gradually supplanted Braille in its traditional forms over the last two decades. Before long, scools and educators followed suit, especially after the introduction of integrated schooling. Their focus shifted from Braille literacy to computer skills mostly ignoring modern Braille technologies.

Hungaryan contracted Braille is much simpler and hence less efficient than English or German grade 2, and the number of its readers is on the decline. Sweeping new reforms have been stepped up and recently been introduced in official publications and lately in textbooks. These reforms left teachers and students in confusion and discouraged many Braille enthusiasts (the number of subscribers to Hungarian Braille periodicals dropped dramatically).

Writing Braille already fell into disuse in the early 1990s, with ten-finger typing on standard computer keyboards taking precedence. However, a new shift is witnessed as

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entering text on the small touch screens of today's smartphones poses a challenge for the blind. Surprisingly or not, On-screen input methods based on Braille just appear to be the most effective. Dormant skills of those who learnt Braille at school were quickly recovered and adapted to this new interface. Others face the challenge of learning it from scratch on their own as no formal training is available in Hungary for chorded braille entry on touch screens.

We aimed our research at the assessment of the current state of Braille, in particular at its usage on smart devices in Hungary. Our paper will discuss the findings of a survey combined with a series of Braille input efficiency measurements conducted with active Braille users.

2 Research Idea

In the first round, ten Hungarian regular Braille users of different backgrounds were invited to participate in our research. The idea was to let them go through the same set of Braille writing related tasks all based on the same short Hungarian text. These tasks included Braille entering tests performed on their own smartphones, and using other less familiar devices made available for the occasion, a single-finger dot-after-dot entry and a so-called chorded entry, entering on the sheer touch screen and on a screen covered by a Braille mask then on a connected keyboard, with one hand and with two hands, using uncontracted (grade 1) and contracted (grade 2) Braille.

In the second round, five regular Braille users (also from Hungary) were involved, practically going through the same set of tests but this time based on multiple texts in various different languages including English, German, Esperanto and Russian. In another bilingual set of texts, these foreign languages were combined with Hungarian (i.e., Hungarian + English, Hungarian + German, etc.). Where possible, grade 2 Braille was also tested with these texts. The idea behind these tests were to assess the differences in efficiency of the Braille systems involved and the subjects' adaptation to them, plus the difficulty of changing the input language on the fly.

Furthermore, a joint survey was conducted with the aim of getting a full picture on Braille used in Hungary on mobile devices. Our goal is to summarize in this paper the results and issues encountered during these tests and in the survey, with the hope that raising awareness may help find solutions and so the status of Braille on smart devices would be consolidated in our region.

3 State of the Art

- MObile SlateTalker (MOST) [1–3]: A self-voiced Android app that is a package of useful applications for the visually impaired. A special mask assists in using the on-screen Braille input surface either in a dot-after-dot or in a chorded manner. The app's unique feature is a comprehensive haptic feedback system for the deaf-blind.
- mBraille [4]: A versatile app suite with full-screen Braille input for iOs and Android devices with proprietary gestures and dot-commands. Important: a simultaneous use

of both hands and up to six fingers is required for the operation of the screen surface dedicated to Braille input, plus, on Android the app is functional only with the screen reader being suspended.

- BrailleTouch [5]: A mobile app providing a proprietary multitouch braille input method on touch screen powered iOs devices. It only supports the major languages and braille systems. References to publications of related research on input efficiency and other materials can be found on the project's website [6]. There is an Android app with the same name on the Google Play Store, but it may be an unrelated project with French support.

4 Methodology

Fifteen select blind Braille users were invited to participate in the research on a voluntary basis (ten for the first round and five more for the second round). The first group consisted of four females and six males, their ages ranging between 14 and 71 with an average of 49, while the second group consisted of all males. Four of them were teachers. Programmers, musicians, a lawier and other professions were also represented, plus a young blind student.

A short text was composed in Hungarian to be embossed both in grade1 and grade 2 braille. It served as a basis for the first round of our efficiency tests. This text consists of three sentences of medium complexity. Each test subject was given a leaflet with this text to study and memorise. Participants were then made to perform a series of Braille writing tests based on the text. The second group was given multiple texts in English, German, Esperanto, Russian and also in combination with Hungarian.

Three input devices were involved: a Mobile Slate Talker [2] powered Android phone with a braille mask placed over its touch screen, a wireless keyboard serving as an electronic brailler, and an iPhone offering a third-party on-screen chorded braille input method [4]. Subjects were called on to enter the text on each input device using the modalities relevant to their physical abilities and the device currently in use.

An app installed on the Android device allowed for a sequential single-finger (dot-after-dot) entry, plus a chorded (simultaneous multifinger) entry, in contracted or uncontracted braille assisted with a mask placed over the touch screen. The same Android app made it possible to enter the text on a connected wireless keyboard providing two-hand and single-hand layouts for braille input. The mBraille app installed on an iPhone provided an input method limited to an on-screen chorded input and to uncontracted braille on the naked screen.

Thus in total, nine different kinds of measurement could be performed by a single participant based on one of the texts provided. Subjects had the choice to skip or repeat any of the measurements. At each test stage, the times required for entering the text were measured and associated with the particular kinds of input. An audio footage was also made during many of the sessions to facilitate later in-depth analysis. When requested, the relevant bit of the text was read aloud for support during the tests. Subjects were instructed to produce a flawless output (i.e., containing the right capitalization if relevant and no typos undealt with).

Table 1. Properties of the sample texts in contracted and uncontracted Braille.

		Grade 1	Grade 2
Length (cells)		163^{H}; 155^{E}; 159^{HE}; 153^{G}; 151^{HG}; 158^{Eo}; 197^{HEo}; 175^{R}; 164^{HR}	117^{H}; 116^{E}; 128^{HE}; 106^{G}; 118^{HG}
Compared to print	Saved (characters):	2^{H}; -4^{E}; 2^{HE}; 12^{G}; 9^{HG}; -2^{Eo}; -1^{HEo}; -5^{R}; 2^{HR}	48^{H}; 35^{E}; 33^{HE}; 59^{G}; 42^{HG}
	Shrink factor (%):	1.2^{H}; -2.6^{E}; 1.2^{HE}; 7.3^{G}; 5.6^{HG}; -1.3^{Eo}; -0.5^{HEo}; $-2;9^{R}$; 1.2^{HR}	29.1^{H}; 23.2^{E}; 20.5^{HE};35.8^{G}; 26.3^{HG}
Compared to grade 1	Saved (characters):	–	46^{H}; 39^{E}; 31^{HE}; 47^{G}; 33^{HG}
	Shrink factor (%):	–	28.2^{H}; 25.2^{E}; 19.5^{HE}; 30.7^{G}; 21.9^{HG}
Sequential entry	Total dots:	568^{H}; 533^{E}; 537^{HE}; 518^{G}; 512^{HG}; 518^{Eo}; 664^{HEo}; 630^{R}; 575^{HR}	387^{H}; 378^{E}; 433^{HE}; 358^{G}; 399^{HG}
	Text dots:	405^{H}; 378^{E}; 378^{HE}; 365^{G}; 361^{HG}; 360^{Eo}; 467^{HEo}; 455^{R}; 411^{HR}	270^{H}; 262^{E}; 305^{HE}; 252^{G}; 281^{HG}
	Spaces:	23^{H}; 26^{E}; 25^{HE}; 26^{G}; 24^{HG}; 24^{Eo}; 29^{HEo}; 29^{R}; 26^{HR}	19^{H}; 26^{E}; 20^{HE}; 26^{G}; 21^{HG}
	Auxiliary dots:	140^{H}; 129^{E}; 134^{HE}; 127^{G}; 127^{HG}; 134^{Eo}; 168^{HEo}; 146^{R}; 138^{HR}	98^{H}; 90^{E}; 108^{HE}; 80^{G}; 97^{HG}
	Average dots/cells:	3.5^{H}; 3.4^{E}; 3.4^{HE}; 3.4^{G}; 3.4^{HG}; 3.3^{Eo}; 3.4^{HEo}; 3.6^{R}; 3.5^{HR}	3.3^{H}; 3.3^{E}; 3.4^{HE}; 3.4^{G}; 3.4^{HG}
Chorded entry	Total dots:	428^{H}; 404^{E}; 403^{HE}; 391^{G}; 385^{HG}; 384^{Eo}; 496^{HEo}; 484^{R}; 437^{HR}	289^{H}; 288^{E}; 325^{HE}; 278^{G}; 302^{HG}
	Text dots:	405^{H}; 378^{E}; 378^{HE}; 365^{G}; 361^{HG}; 360^{Eo}; 467^{HEo}; 455^{R}; 411^{HR}	270^{H}; 262^{E}; 305^{HE}; 252^{G}; 281^{HG}
	Spaces:	23^{H}; 26^{E}; 25^{HE}; 26^{G}; 24^{HG}; 24^{Eo}; 29^{HEo}; 29^{R}; 26^{HR}	19^{H}; 26^{E}; 20^{HE}; 26^{G}; 21^{HG}
	Average dots/cells:	2.6^{H}; 2.6^{E}; 2.5^{HE}; 2.6^{G}; 2.5^{HG}; 2.4^{Eo}; 2.5^{HEo}; 2.8^{R}; 2.7^{HR}	2.5^{H}; 2.5^{E}; 2.5^{HE}; 2.6^{G}; 2.6^{HG}

5 Results

5.1 About the Text

Grade 2's shrink factor varies by text and language. Respecting the number of Braille dots entered, chorded entry is more efficient because the auxiliary dots (corresponding to the "cell completed" function in sequencial entry) are out of the play. This is why auxiliary dots are not shown for chorded entry. Sequencial dot entry aided by a mask is chosen by those who prefer or are only able to use one hand.

Superscript letters next to the numeric values refer to the language(s) of the text related to that value (i.e., H: Hungarian, E: English, G: German, Es: Esperanto, R: Russian, HE: Hungarian + English, etc.).

Table 2. Entry speeds summarized for the test subjects using different input methods

One-hand entry: 8^{H}; 5^{E}; 5^{HE}; 5^{G}; 5^{HG}		Grade 1	Grade 2
On masked screen	People	8^{H}; 5^{E}; 5^{HE}; 5^{G}; 5^{HG}	8^{H}; 3^{E}; 3^{HE}; 3^{G}; 3^{HG}
Newbie: 4^{H}; 3^{E}; 3^{HE} Skipped: 1^{H}; 0^{E}; 0^{HE}	Fastest:	20.2^{H}; 20.1^{E}; 22.5^{HE}; 23^{G}; 24.3^{HG}	30.9^{H}; 22.7^{E}; 24.8^{HE}; 30^{G}; 28.2^{HG}
	Mean:	9.4^{H}; 10.7^{E}; 13.8^{HE}; 13^{G}; 13.8^{HG}	12.8^{H}; 18.4^{E}; 18.7^{HE}; 21.6^{G}; 20.7^{HG}
	Slowest:	3.8^{H}; 3.3^{E}; 5.1^{HE}; 4.3^{G}; 5.1^{HG}	4.5^{H}; 9.9^{E}; 9.1^{HE}; 9.6^{G}; 9.3^{HG}
On keyboard	People:	3^{H}; 2^{E}; 2^{HE}; 2^{G}; 2^{HG}	3^{H}; 2^{E}; 2^{HE}; 2^{G}; 2^{HG}
Newbie: 8^{H}; 4^{E}; 4^{HE} Skipped: 7^{H}; 3^{E}; 3^{HE}	Fastest:	44^{H}; 39.4^{E}; 42^{HE}; 42.1^{G}; 45.7^{HG}	58.2^{H}; 44.2^{E}; 44.9^{HE}; 52.1^{G}; 48^{HG}
	Mean:	24.2^{H}; 37.8^{E};39.9^{HE}; 41.3^{G}; 44.2^{HG}	35.6^{H}; 43.3^{E}; 43^{HE}; 50.8^{G}; 45.8^{HG}
	Slowest:	9.8^{H}; 36.2^{E}; 37.9^{HE}; 40.4^{G}; 42.7^{HG}	15.5^{H}; 40.3^{E}; 41.1^{HE}; 49.5^{G}; 43.6^{HG}
Two-hand entry: 9^{H}; 5^{E}; 5^{HE}; 4^{G}; 4^{HG}			
On masked screen	People:	5^{H}; 5^{E}; 5^{HE}; 4^{G}; 4^{HG}	5^{H}; 3^{E}; 3^{HE}; 3^{G}; 3^{HG}
Newbie: 9^{H}; 3^{E}; 3^{HE} Skipped: 5^{H}; 0^{E}; 0^{HE}	Fastest:	34.1^{H}; 27^{E}; 33.3^{HE}; 34.7^{G}; 36.2^{HG}	48.3^{H}; 34.8^{E}; 37.9^{HE}; 41.3^{G}; 45.7^{HG}
	Mean:	20.1^{H}; 17.3^{E}; 21.4^{HE}; 26.2^{G}; 27.1^{HG}	29.7^{H}; 28.5^{E}; 29.8^{HE}; 32.7^{G}; 35.5^{HG}
	Slowest:	12.1^{H}; 3.6^{E};7.5^{HE}; 18.9^{G}; 19^{HG}	17.7^{H}; 17.1^{E}; 15.7^{HE}; 18.2^{G}; 20^{HG}
On naked screen	People:	7^{H}; 4^{E}; 4^{HE}; 4^{G}; 4^{HG}	
Newbie: 5^{H}; 2^{E}; 2^{HE}; 2^{G}; 2^{HG}	Fastest:	36.7^{H}; 27.9^{E}; 36.5^{HE}; 34.1^{G}; 40.9^{HG}	
Skipped: 3^{H}; 0^{E}; 0^{HE}; 0^{G}; 0^{HG}	Mean:	24.9^{H}; 22.6^{E}; 28.9^{HE}; 26.6^{G}; 28.8^{HG}	
	Slowest:	7.9^{H}; 15.8^{E}; 16.4^{HE}; 18.9^{G}; 16.4^{HG}	
On keyboard	People:	9^{H}; 4^{E}; 4^{HE}; 4^{G}; 4^{HG}	8^{H}; 3^{E}; 3^{HE}; 3^{G}; 3^{HG}
Newbie: 4^{H}; 4^{E}; 4^{HE}; 4^{G}; 4^{HG}	Fastest:	47.1^{H}; 41.2^{E}; 48.3^{HE}; 55^{G}; 53.3^{HG}	58.2^{H}; 45.3^{E}; 53.7^{HE}; 52.1^{G}; 51.9^{HG}
Skipped: 1^{H}; 1^{E}; 1^{HE}; 1^{G}; 1^{HG}	Mean:	26.3^{H}; 31.9^{E}; 42.2^{HE}; 46.1^{G}; 46.7^{HG}	34.8^{H}; 38.6^{E}; 44.9^{HE}; 45.1^{G}; 45.8^{HG}
	Slowest:	9.2^{H}; 20.8^{E}; 29.7^{HE}; 30.5^{G}; 34.9^{HG}	14.9^{H}; 29.2^{E}; 32.7^{HE}; 32.5^{G}; 36.2^{HG}

5.2 Speed Tests

In Table 2, integer numbers represent participants, decimals indicate typing rates expressed in words per minute (wpm). "Newbie" shows the number of participants new to a particular method or device, "Skipped" refers to newbies unwilling or unable to complete the test in question. Superscript letters indicate the language(s) of the sample text used for the test yielding the value (see the explanation for Table 1).

In capable hands, certain types of Braille input can be fairly fast. For reference, an experienced blind person typing on a PC keyboard with ten fingers can enter our short Hungarian text flawlessly within 24 s i.e., 82.5 words per minute. On a Braille enabled PC keyboard, the fastest rate measured with one of the test subjects was 32 s (58.2 wpm) typed in grade 2. A mask assisted chorded input yielded 41 s (48.3 wpm) in grade 2. Input efficiency also relies on the way typos can be avoided or removed when entering text on a touch-screen.

5.3 About Hungarian Contracted Braille

Tests revealed that the subjects were rather inexperienced in writing grade 2 as it was mostly encountered so far when reading Braille. For some, it was the first time to actually write any text using this contraction system. After spending some time with this feature, all iPhone using participants regretted that Hungarian grade 2 Braille was not available for them. This issue may be dealt with by coordinated contributions to the open-source LibLouis project.

According to our survey, most participants keep the spell checker and autocorrection features disabled for Braille input because they find it cumbersome to tackle with the offered suggestions. Writing in Hungarian contracted Braille reduces the typo rate. This is not only because grade 2 reduces the number of Braille cells to be entered, but by the contractions themselves, also the number of dots to be entered is reduced (see Table 3).

Dot patterns consisting of 4–6 Braille dots are more prone to typos. Therefore grade 2 applied over our Hungarian text comes with numerous benefits. Hungarian grade 2 not only reduces the number of cells to be entered but also reduces the number of the so-called heavy cells (consisting of 4–6 dots) and often introduces light cells (having

Table 3. Comparative table on dot pattern statistics.

Pattern type	Instances in grade 1	Instances in grade 2	Reduction (%)
1-dot cells	16^{H}; 9^{E}; 19^{HE}; 9^{G}; 13^{HG}; 20^{Eo}; 19^{HEo}; 7^{R}; 12^{HR}	16^{H}; 12^{E}; 19^{HE}; 6^{G}; 12^{HG}	0^{H}; -33.3^{E}; 0^{HE}; 33.3^{G}; 7.7^{HG}
2-dot cells	36^{H}; 29^{E}; 29^{HE}; 40^{G}; 37^{HG}; 33^{Eo}; 50^{HEo}; 36^{R}; 33^{HR}	26^{H}; 20^{E}; 20^{HE}; 21^{G}; 26^{HG}	27.8^{H}; 31^{E}; 31^{HE}; 47.5^{G}; 29.7^{HG}
3-dot cells	42^{H}; 59^{E}; 49^{HE}; 37^{G}; 38^{HG}; 50^{Eo}; 52^{HEo}; 42^{R}; 45^{HR}	26^{H}; 31^{E}; 36^{HE}; 23^{G}; 28^{HG}	38.1^{H}; 47.5^{E}; 26.5^{HE}; 37.8^{G}; 26.3^{HG}
4-dot cells	39^{H}; 26^{E}; 31^{HE}; 40^{G}; 35^{HG}; 31^{Eo}; 43^{HEo}; 55^{R}; 42^{HR}	26^{H}; 19^{E}; 27^{HE}; 19^{G}; 24^{HG}	33.3^{H}; 26.9^{E}; 12.9^{HE}; 52.5^{G}; 31.4^{HG}
5-dot cells	7^{H}; 6^{E}; 6^{HE}; 1^{G}; 4^{HG}; 4^{HEo}; 6^{R}; 6^{HR}	4^{H}; 7^{E}; 6^{HE}; 7^{G}; 5^{HG}	42.9^{H}; -16.7^{E}; 0^{HE}; -600^{G}; -25^{HG}
6-dot cells	0^{E}; 0^{G}; 0^{HG}	1^{E}; 4^{G}; 2^{HG}	

1–3 dots). The reduction of the total number of dots entered directly translates to benefits for sequential entry and comes with indirect benefits for chorded entry, since heavy cells have the potential to produce more typos.

6 Impact and Contributions to the Field

Our findings may help app developers and AT designers better profile their Braille related solutions, especially in handling contractions and typos in mobile environments. Extension of the Grade 2 support to further languages including Hungarian may be stimulated by our paper raising the awareness of those contributing to the open-source LibLouis project.

Data collected during our research may serve as the base of further studies e.g. on how best to reduce stress caused by the acoustic and mental overload on the users being forced to maintain multilevel concentration and exposed to an increased amount of artificial and often polyphonic speech while using Braille input methods on mobile devices.

40 % of our test subjects in the first group are teachers at a special school for the blind and active Braille users. By their help, the methodology for a new training scheme for writing Braille on the touch screen may be worked out for the benefit of many blind smartphone users.

7 Conclusion

Courtesy to the Budapest School and Methodology Centre for the Blind, Our Rehabilitation-Technology Laboratory has successfully conducted tests and a joint survey with select Hungarian blind Braille users. The research has produced a great wealth of data about Braille input efficiency on mobile devices and helped identify and address important issues. The same data may be used for further research in this field.

References

1. Markus, N., Malik, S., Juhasz, Z., Arató, A.: Accessibility for the blind on an open-source mobile platform. In: Miesenberger, K., Karshmer, A., Penaz, P., Zagler, W. (eds.) ICCHP 2012, Part II. LNCS, vol. 7383, pp. 599–606. Springer, Heidelberg (2012)
2. Mobile Slate Talker (MOST). http://rehab.wigner.mta.hu/?q=en/node/34
3. Juhasz, Z., et al.: Usability evaluation of the MOST mobile assistant (SlatTalker). In: Miesenberger, K., Klaus, J., Zagler, W.L., Karshmer, A.I. (eds.) ICCHP 2006. LNCS, vol. 4061, pp. 1055–1062. Springer, Heidelberg (2006)
4. Pasanenm, H.: mBraille. http://mpaja.com/mbraille
5. Romero, M.: BrailleTouch, Georgia Institute of Technology (USA). http://www.cc.gatech.edu/~mromero/brailletouch/
6. Southern, C., Clawson, J., Frey, B., Abowd, G., Romero, M., An evaluation of BrailleTouch: mobile touchscreen text entry for the visually impaired. In: MobileHCI 2012, (Full Paper), San Francisco, September 2012