Dot shape and legibility analysis of multilayer UV ink-jet printed Braille text

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Abstract: *Multilayer UV ink-jet is recognized as alternative printing technology to traditional embossing, thermo-forming, screen-printing and other Braille printing techniques. Advantages of multilayer printing are extensive possibilities of dot shape and dot height modulation according to the requirements of blind and visually impaired people associations and legislation.*

Braille used for the pharmaceutical packaging is prescribed according to EU Directive 2004/27/EC, cell and dot dimensions are specified in the Standard EN 15823, in other fields there are only recommendations and specifications in force. Braille is usually adapted to different users, languages, scope, media, and printing processes.

A set of samples with different Braille text sizes using conventional rounded dot shape and alternative dot shapes with additional small raised dot over basic dot, dots with incision and other dot shapes were prepared using multilayer UV ink-jet printing technique. Cell and dot dimensions and shape profile were obtained using different profile-meters and image analysis techniques.

Legibility test has been carried out at the „Zavod za slepo in slabovidno mladino Ljubljana“ (Centre to help blind and partially sighted persons) and with the help of other blind people of all ages and Braille skills. It is evident from the results that the successful reading of the blind is greatly dependent on the shape and height of the dots of Braille. A survey on their answers and their comments gave us important information and directions for further research.

Keywords: *Braille, legibility, blind and weak-sighted, UV ink-jet printing, dot profile*

1 Introduction

Main goal of our investigation aims to determine whether or not the quality of multilayer UV ink-jet printing technique is good enough to print good legible Braille text. Braille can adequately be printed using traditional techniques, such as embossing, different art of thermo-forming and screen-printing, however we presume that by using digital printing technique dot shapes are more easily repeatable than with any other technique and wide variability of shapes become available.

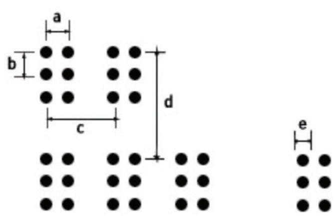
Braille is adapted to various forms of blindness. People, who are born blind, can easily read smaller dots with less relief, however, people, who lost their sight later in life or due to injuries, read bigger dots with larger relief more easily. There are different Braille guidelines for printing [1], i.e. Small English, ECMA Euro Braille, and English Giant Dot. The reasons for choosing the mentioned three guidelines from more than 20 different specifications were following: ECMA Euro Braille was chosen because its size is in accordance to standards and recommendations, English Giant Dot was chosen because of its potential to be used in the educational system, and Small English because of its small shapes since our research aims to determine minimal size of Braille the blind are still able to read.

There are 285 million people who are blind or visually impaired worldwide, among them 39 million are blind and 246 million have low vision. There are four levels of visual function, according to the International Classification of Diseases: normal vision, moderate visual impairment, severe visual impairment and blindness. Blindness is the condition of lacking visual perception due to physiological or neurological impacts, clinically recorded as NLP – "no light perception", however blindness is frequently described as visual impairment with less than 0.3 of normal visual acuity. [2, 3]

EC Directive 2004/27 requires labeling and information for the blind to be provided with medicinal products. Dimensions of Braille printed on pharmaceutical packaging are specified in the Standard EN 15823, however for general use there are only recommendations and specifications available. [4, 5, 6]

2 Background

Braille, developed to its full extent in 1825 by young Frenchman Louis Braille, basically consists of a base set-up of 2 dots horizontally and 3 dots vertically. This gives a total 26 dot combinations, 64 in all. As one of the 64 combinations is all zeros – all dots not present – this is considered as the space rather than a real Braille character (Figure 1).



Dimensions:
a = 2.5 mm
b = 2.5 mm
c = 6.0 mm between two letters of one word
d = 10.0 mm +0.0 mm / -0.1 mm line spacing
e = 1.3–1.6 mm is dot diameter

Figure 1: Typical layout of Braille according to the Marbach Medium standard (equal to the ECMA Euro Braille specification)

The ability to read Braille by sense of touch and transfer of the information through the fingers to create understanding, recollection or simple factual recognition requires that the Braille is fully legible, that the user masters the Braille characters and the tactile sense of the blind user is intact.

Braille is typically applied to packaging through embossing on the press, die-cutter or even folder-gluer, which is the common process for pharmaceuticals, or with the addition of ink-jet or screen-printed label. Labels tend to be more robust than embossing, which can be flattened during transport, or fail to achieve sufficient dot height because the board is too thick or fragile.

There are small differences in symbol dimensions between national Braille systems. To avoid problems the Marbach Medium standard Braille is strongly recommended for pharmaceutical packaging by EC Directive. The height of the dots is not specified for Marbach Medium standard. In the Standard EN 15823:2010 dot height is specified at 0.20 mm. Braille dot height in national standards and recommendations (not for packaging) vary from 0.25 mm in Sweden up to 1.0 mm in France. International standard Braille dot height for buildings (i.e. elevators) is from 0.6 to 0.9 mm. [1]

Legibility study on pharmaceutical packaging, concluded in 2008 by the University of Birmingham and RNIB in cooperation with other European institutions, where dot height in the range of 0.06 to 0.23 mm was studied, found the acceptable height of raised Braille dots to be 0.18 mm (67 % of participants definitely recognize text, 27 % probably), but cracking of a board surface was present at this height [7].

Another difficulty is the measurement method of the height of Braille dots. The use of standard thickness gauge is not suitable because of soft, sensitive dots, the more sophisticated methods, like PixelProof device, are expensive and final evaluation of the results is not always reliable. [8, 9, 10]

3 Experimental

Samples for evaluation were prepared using InkJet Roland DG LEC-330 UV digital large format printer, applying different modulation of Braille dots. Dot height on printed samples of pharmaceutical packaging boxes was measured using thickness gauge and LM1 laser profilemeter (handheld device using visual measurement option). Dot height at the second set of experiments was measured using mechanical profilometer MarSurf PCV/CD 120 with probe tip CP 350-M7 and image analysis technique based on microscopic images. [11]

After preliminary tests of multilayer UV ink-jet printing technique used for Braille printing on pharmaceutical packaging and investigations of different dot shapes [9, 11] we prepare new set of samples using three different Braille specifications (Table1).

Table 1: Basic characteristics of three different Braille specifications

Specification name	Horiz. dot to dot (mm)	Vert. dot to dot (mm)	Cell to cell (mm)	Line to line (mm)	Dot base diam. (mm)	Dot height (mm)
	a	b	c	d	e	f
Small English	2.03	2.03	5.38	8.46	1.4–1.5	0.33
ECMA Euro Braille	2.50	2.50	6.00	10.00	1.30	0.50
English Giant Dot	3.25	3.25	9.78	17.02	1.90	0.81

Dot height of Small English Braille was achieved by using 3 layers of UV matt varnish (0.25 mm measured by using profilometer MatSurf), ECMA Euro Braille by using 6 layers (0.36 mm) and English Giant Dot by using 10 layers (0.54 mm), all applied over one layer of clear overprint varnish with preprinted braille dots in black. Lower profile height is due to spilling of varnish. Printed text for evaluation is shown in Figure 2. Figures 3 to 5 show us profiles and shape of printed Braille.

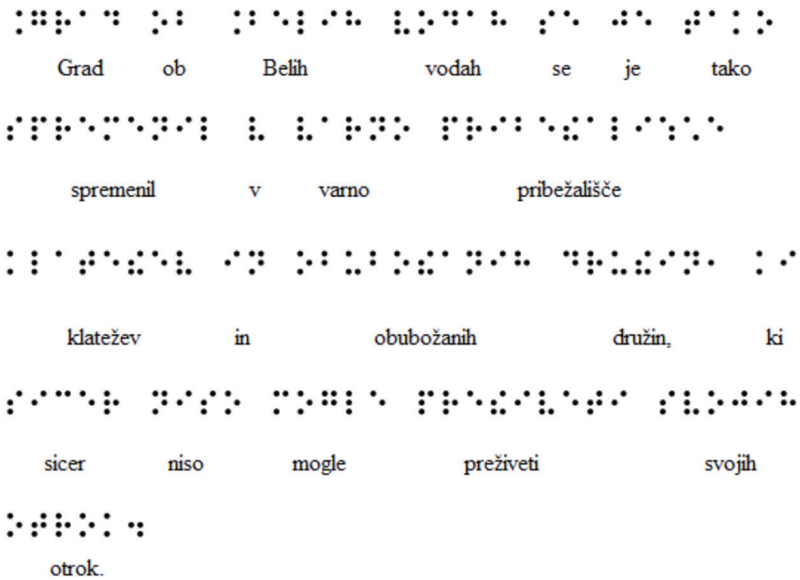


Figure 2: Text (in Slovene) printed for the evaluation of Braille legibility

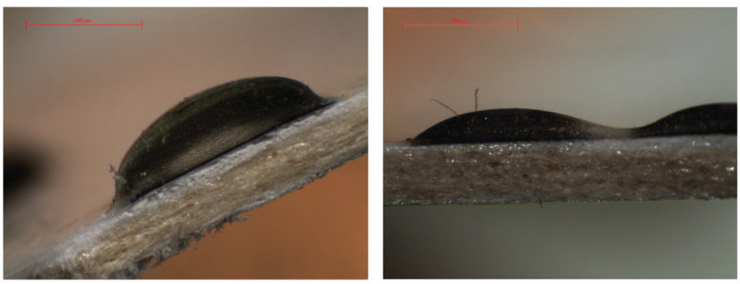


Figure 3: Cross-cut of English Giant dot (left) and Small English (right) Braille dots. On English Giant Dot picture preprinted black layer is clearly visible, on Small English spilling of varnish prevents precise measurement and reading

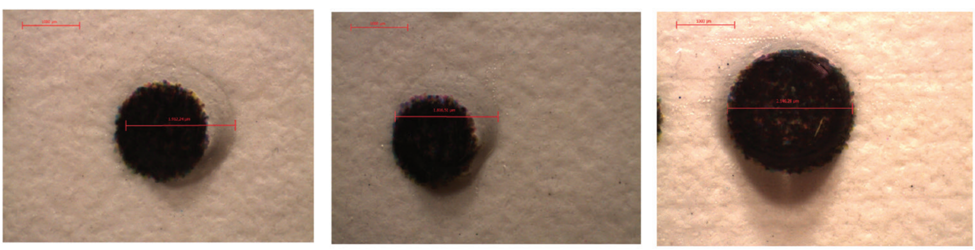


Figure 4: Pictures of Small English, ECMA Euro Braille and English Giant Dot printed Braille dots with clearly visible increased diameter caused by spilling of varnish

Main results of the evaluation of three different printed texts are presented in Table 2. General opinion of blind persons was positive, experienced readers are capable to read very fast without reading errors. All of them declare ECMA Euro Braille printed text as best legible.

Table 2: Main results of reading test with blind people

Person	Gender	Age (years)	Braille literacy (years)	Are all prints legible?	Reading time (s)			Reading errors
					Small English	ECMA Euro Braille	English Giant Dot	
1	female	12	6	yes	60	60	60	1
2	female	16	10	yes	30	30	30	0
3	male	19	14	yes	30	30	30	0
4	male	75	66	no	>60	60	>60	5
5	male	59	>50	yes	60	60	60	2
6	female	26	20	yes	60	<60	60	0
7	male	34	25	yes	60	<60	60	0
8	male	58	>45	no	>60	60	60	1
9	male	60	50	no	>60	60	60	2
10	male	54	>45	yes	>60	60	60	2
11	male	31	20	yes	60	60	60	0
12	male	17	11	yes	60	60	60	1

Next step in our investigation was assessment of legibility and usefulness of multilayer UV ink-jet printed Braille with different shape of the dots.

A set of samples were prepared on the basis of preliminary tests [11], where dot shapes were modulated using 3 or 5 layers of UV varnish, printed on a substrate or on a overprint varnish layer, to achieve proper height. As an option, 3 additional layers have been added for rendering the top surface of a Braille dot. Cracked Braille dot was simulated using printed incision and rough surface with a microdot at the surface of the dot peak.

Finally we try to achieve additional shapes of dots using 5 basic varnish layers for basic dot and additional 5 layers for added horizontal and vertical line, triangle, square, star, pyramid and other shapes on the top of the Braille dot. Results are shown in Figure 5 and 6.

First assessment of Blind persons was very positive, even not very experienced Braille readers recognize and distinguished different dot shapes.

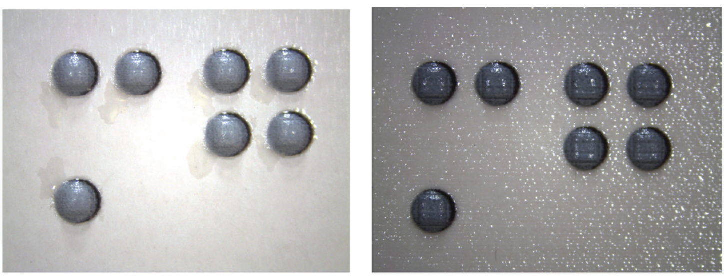


Figure 5: Braille dots with added square, printed on coated cardboard (left) and pre-varnished cardboard (right) with pre-printed black. Spilling of varnish is clearly visible on coated only cardboard

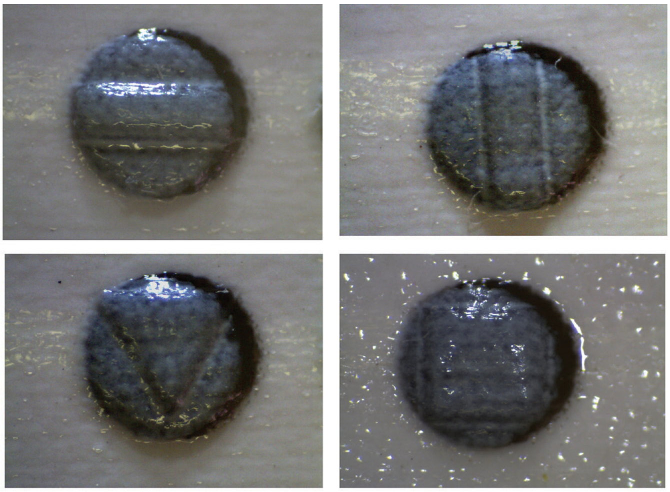


Figure 6: Horizontal line, vertical line, triangle and square were printed on pre-varnished layer with high precission at the top of Braille dot

4 Conclusions

The results of the research can't be fully satisfied even though we have achieved most of our goals. Multilayer UV ink-jet printing technique has been proved as suitable technique for Braille printing in the case when time and costs are not most important parameters in investigation, however a lot of improvement should be done to improve the printing process, substrates, inks and varnishes and to eliminate process deficiences.

Measurement methods are not appropriate, specifically in the case of measurement of the dot profile printed by using clear varnishing or in the case of special shape of the dots. Results of the measurements using different methods like profilemeter and image analysis are not the same and are thus unreliable.

The number of samples of both experiments and involved blind persons with Braille literacy was not high enough to get optimal statistically valid answers and confirmations. It is evident that even blind persons that are not perfect Braille users can use good UV printed Braille text.

Different shapes of the dots, used for text emphasis, titles, numbers, footnotes and other text features should improve the number of readable information and Braille reader experience.

Improvements of ink-jet printed Braille text are in progress. Further improvements in our research work on Braille legibility are expected by optimizing the shape of digital printed dots, optimized for blind readers with lower reading skill.

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