LETTER

Determining the Optimum Font Size for Braille on Capsule Paper

Tetsuya WATANABE[†a)], ***Member***

SUMMARY Braille fonts allow us to easily make braille labels on capsule paper. For legibility, fonts should be printed at optimum sizes. To find the optimum sizes for Japanese braille fonts, we conducted an experiment in which a Japanese braille font was printed at various sizes on capsule paper and read and rated by young braille users. The results show that braille printed at 17 and 18 point sizes were read faster and evaluated higher than those printed at smaller or bigger sizes.
key words: *braille fonts, capsule paper, tactile reading, legibility*

1. Introduction

Capsule paper is a method of producing tactile graphics for blind people. Its surface is coated with microcapsules which swell up when heated. The user prints or draws on this paper with black ink and exposes it to powerful light in the fuser. In this way the black-drawn part is heated and raised to be tangible. Capsule paper is also known as microcapsule paper, swell paper, or flexi paper.

Braille fonts allow us to easily add braille labels to tactile graphics on capsule paper [1]. These days, several kinds of braille fonts are available on the Web. Among these, fonts that correspond to the Japanese *kana* alphabet are convenient for printing Japanese. Braille font developed by Nippon (Japan) Lighthouse is popular in Japan as this institute is well known in the field of vision rehabilitation [2]. In fact, we are using this font in our tactile map automated creation system [3].

Braille fonts can be printed at arbitrary sizes by changing the font size in illustration or word processor software. However, proper sizes should be selected for these fonts to be read easily. Duxbury Systems, Inc., a leading company in braille-translation software in the U.S., states that printing its font at a point size of 22 makes normal-sized braille [4]. The Royal National Institute for the Blind (RNIB) in the U.K. recommends printing the Duxbury Braille Font at 24 points on capsule paper [5]. As experimental results that confirm this size to be optimum cannot be found in related journals, these values are thought to be empirical.

We once explored the relationship among braille dimensions, dot diameters, and the legibility of braille experimentally [6]. The result was that braille whose dot diameter ranged from 1.17 to 1.43 mm and whose interdot space ranged from 2.49 to 2.73 mm vertically and 2.24 to 2.45 mm horizontally was read in shorter times and rated higher (as for types of interdot spaces of braille, see Fig. 1). However, the stimuli in this experiment were made with illustration software, and their dimensions and dot diameters differed from those of braille made with braille fonts. For the sake of practitioners in vision rehabilitation and education for the blind and assistive technology developers like us, information on the optimum point size for a certain braille font is necessary. Thus, we decided to explore this subject with a popular Japanese braille font.

Manuscript received February 18, 2014.
Manuscript revised April 11, 2014.
[†]The author is with the Faculty of Engineering, University of Niigata, Niigata-shi, 950–2181 Japan.
a) E-mail: t2.nabe@eng.niigata-u.ac.jp
DOI: 10.1587/transinf.E97.D.2191

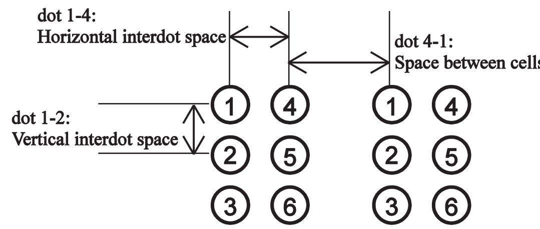

Fig. 1 Types of interdot spaces of braille.

2. Experiment

An experiment was conducted in which a popular Japanese braille font was printed at various sizes on capsule paper and read and rated by braille users.

2.1 Participants

The participants were seven blind persons, aged 19 to 21, who read braille on a daily basis.

2.2 Stimuli

A braille font from the Information and Culture Center for the Blind, Nippon Lighthouse was used (hereinafter referred to as NL Braille Font) [2]. The font size was changed from a point size of 15 to 22 in 1 point steps in the word processor software Microsoft Word. The dot diameters and dimensions of the braille printed at each size are shown in Table 1.

Several sets of five sheets of braille on capsule paper were prepared for the experiment. Each sheet had eight lines of braille sentences that were printed at eight different points in a random order. Each line had 20 characters that were divided into four five-character blocks. All blocks were meaningless words consisting of randomly arranged characters so

Table 1 Dimensions of NL Braille Font printed at various sizes.

Size [point]	Dot diameter [mm]	Vertical interdot space [mm]	Horizontal interdot space [mm]	Distance between cells [mm]
15	1.41	1.99	2.17	3.12
16	1.49	2.10	2.34	3.30
17	1.59	2.26	2.48	3.51
18	1.69	2.37	2.61	3.76
19	1.79	2.48	2.75	3.94
20	1.90	2.65	2.92	4.18
21	1.98	2.78	3.08	4.37
22	2.09	2.91	3.19	4.59

as to prevent participants from reading ahead.

The braille sentences were printed on DIN A4-sized capsule paper (Zychem, ZY-TEX2) by using a laser printer (Canon, Satera MF4380d). The paper was heated with a heater (Quantum, PIAF) with a heating parameter of around seven (one: low and nine: hot).

2.3 Procedure

The experiment was carried out in a quiet room. The participants sat on a chair and read materials that were placed on a desk. The participants were asked to read materials with their hands in their usual manner. Some used one hand (right or left), and others used both hands. A raised mark on the left side of each line was assigned as the starting position. They were asked to place their fingers at that position before the start of the experiment. When an examiner gave the start signal, the subjects were asked to begin tactually reading the stimulus lines aloud. The time from start to completion of reading aloud was measured with a stopwatch and recorded as the reading time. After reading a line, the subjects were asked to rate the legibility of the braille on a scale of one, least legible, to five, most legible. They were instructed not to make any comparisons to the previous lines.

During the experiment, the actions of each reader's hands were videoed. Reading errors were checked during the experiment and after the experiment was completed; they were confirmed from the video.

3. Results

Out of the five braille sheets that the participants read, the data of the first sheet was removed, and those of the remaining four sheets were used for analysis. Average reading times, ratings, and numbers of errors were calculated for each person and each condition and put to analysis of variance (ANOVA).

3.1 Reading Time

Figure 2 shows the relationship between font size and reading time. The coefficients of variance (= *SD* divided by the mean) of the reading times were around 15% or less for 15 to 20 points. That means that the braille reading skills of the seven participants had a small variance.

The reading time was the shortest at an 18-point size, and a trend was observed that as the size became either smaller or larger than 18 points, the reading time grew longer. This trend was noticeable when the size became larger.

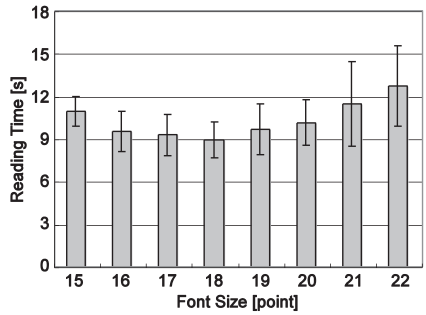

Fig. 2 Relationship between font size and reading time.

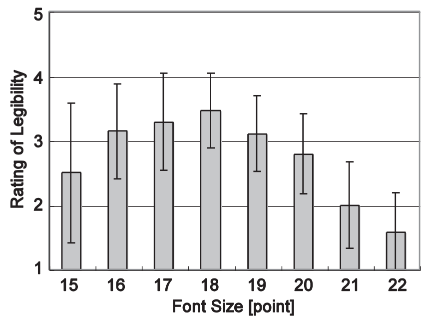

Fig. 3 Relationship between font size and rating of legibility.

An ANOVA revealed a significant difference in reading time for font size ($F(7, 42) = 10.90$, $p < 0.01$). A multiple comparison (1%) using Tukey's method showed significant differences in reading time between point sizes of 21 and both 17 and 18, and between 22 and 16 to 20.

3.2 Rating of Legibility

Figure 3 shows the relationship between font size and rating of legibility. The rating was the highest at 18 points, and a trend was observed that as the size became either smaller or larger than 18 points, the rating grew lower. This trend was noticeable when the size became larger.

An ANOVA revealed a significant difference in the rating of legibility for font size ($F(7, 42) = 11.93$, $p < 0.01$). A multiple comparison (1%) showed significant differences in reading time between point sizes of 21 and 16 to 19, and between 22 and 16 to 20.

3.3 Errors

Figure 4 shows the relationship between font size and reading errors. The number of reading errors was much higher at 15 and 17 points than at other points. However, no consistent relationship was observed between the font size and number of reading errors. An ANOVA did not show a significant difference in the number of reading errors for font

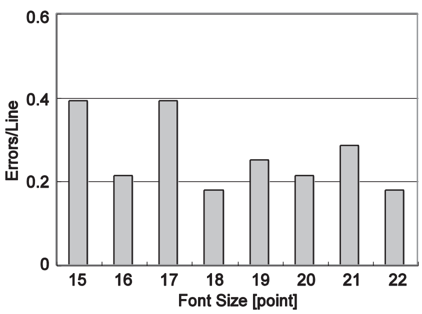

Fig. 4 Relationship between font size and number of reading errors.

size (F (7, 42) = 0.5).

4. Discussion

4.1 Legible Braille Dimension

From the results on the reading time and rating of legibility in which significant differences were found for printed font size, it was clear that braille made with NL Braille Font was most legible when printed at 17 to 18 points. In this discussion, the dimensions of braille at these points are compared with those that were found to be legible in our prior research [6] and those of braille made with the Duxbury Braille Font printed at the recommended size [5].

For comparison, two preparations were made. (1) As the interdot spaces are different between vertical and horizontal for NL Braille Font and the font used in the previous work [6], the average spaces were calculated among the vertical and horizontal interdot spaces for each point and used for comparison. (2) The diameters and dimensions of the braille made with the Duxbury Braille Font for printing purposes as well as the Swell Braille Font were measured and are shown in Table 2. Their vertical and horizontal interdot spaces are the same.

Figure 5 shows that legible braille dimensions from two studies of us and those recommended by RNIB [5] coincide. This increases the reliability of the results of the present experiment.

The participants were young braille users who learned braille at school age. At the same time, another study of us on braille showed that people who started learning braille in their twenties preferred braille whose dimension is larger than the standard [7]. For braille on capsule paper to be legible even to people who start using braille later in life, a further experiment on these people that is designed the same way should be conducted.

4.2 Legible Dot Diameter

Another factor beside dimension that determines legibility is dot diameter. Another previous study of us revealed that among three dot diameters, smaller than the standard size, the standard size, and larger than the standard size, braille with the smallest dot diameter was read with the best reading performance, and this phenomenon was consistent in all

Table 2 Dot diameters and dimensions of braille font from Duxbury Systems, Inc.

Font	Size [point]	Dot diameter [mm]	Vertical interdot space [mm]	Horizontal interdot space [mm]
Braille Font	22	1.38	2.08	2.08
	24	1.50	2.30	2.30
Swell Braille Font	22	1.10	2.10	2.10
	24	1.23	2.28	2.28

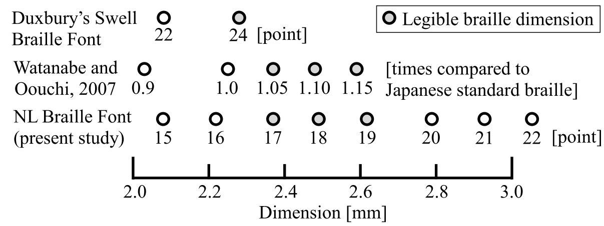

Fig. 5 Comparison of legible braille dimensions.

braille dimension conditions [6].

Duxbury Systems, Inc. distributes free software, called "Braille-Build," that can produce braille fonts with various dot diameters for the purpose of printing on capsule paper [8]. The company states "As a general rule, 80 % is sufficient for Flexipaper." This small dot diameter can be produced with the Swell Braille Font. Braille made with this font at 24 points has the same dimension as normal braille font, but its dot diameter is reduced to 1.23 mm, 80 % of the normal font. This diameter approximates to 1.17 mm, a braille size that was rated the highest in our previous study [6].

On the basis of these facts, it is expected that a new Japanese braille font whose dot diameter is reduced for printing on capsule paper will be developed. At the same time, the fact is that braille with a dot diameter that is too small is raised low and leads to low legibility. Therefore, the relationship among printed dot size, expanded dot size, and legibility should be carefully explored and utilized in developing a new braille font.

5. Conclusion

The present experiment revealed the optimum legible font size for braille on capsule paper. Based on this, we decided to use NL Braille Font at 18 points in our tactile map automated creation system [3].

Future work on this issue is as follows.
(1) Carry out an experiment designed the same but on people who lost their sight later in life.
(2) Explore the relationship among the printed dot size, expanded dot size, and the legibility of braille.
(3) Develop a new Japanese braille font for the purpose of printing on capsule paper.

Acknowledgments

The author would like to thank the braille users who partic-

ipated in the experiment.

Half of this work was done as graduation work by Shinji Saito, who belonged to Watanabe's laboratory in the fiscal year of 2011, and the other half was done by the author.

References

[1] Y. Eriksson and M. Strucel, A Guide to the Production of Tactile Graphics on Swellpaper, AB PP Print, Stockholm, 1995.
[2] Nippon Lighthouse, Braille Font for Printing, http://www.eonet.ne.jp/˜tecti/tecti/br-font.html
[3] T. Watanabe, T. Yamaguchi, K. Watanabe, J. Akiyama, K. Minatani, M. Miyagi, and S. Oouchi, "Development and evaluation of a tactile map automated creation system accessible to blind persons," IEICE Trans. Inf. & Syst. (Japanese Edition), vol.J94-D, no.10, pp.1652–1663, Oct. 2011.
[4] Duxbury Systems, Inc., Free Download of The Braille TrueType Fonts, http://www.duxburysystems.com/product2.asp?product=The Braille TrueType Fonts&level=free
[5] Royal National Institute for the Blind, http://www.rnib.org.uk/livingwithsightloss/reading/how/braille/writing/pages/braille_fonts.aspx
[6] T. Watanabe and S. Oouchi, "A study of legible braille patterns on capsule paper: Diameters of braille dots and their interspaces on original ink-printed paper," Nat. Inst. of Special Education Bulletin, no.8, pp.1–9, 2007.
[7] T. Watanabe, S. Oouchi, and K. Doi, "A study of legibility of enlarged braille," IEICE Trans. Inf. & Syst. (Japanese Edition), vol.J94-D, no.1, pp.191–198, Jan. 2011.
[8] Duxbury Systems, Inc., Braille-Build, http://www.duxburysystems.com/documentation/dbt11.1/miscellaneous/Braille_Build.htm