Creation of a Japanese Typeface Designed for Readers with Dyslexia

Xinru Zhu*, Shohei Yamada, and Kyo Kageura

Graduate School of Education, the University of Tokyo

1 Introduction

This paper introduces our research which aims to create a Japanese typeface and to develop a Japanese typeface customisation system for readers with developmental dyslexia.

1.1 Background

Developmental dyslexia is "a specific learning disability that is neurobiological in origin. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities" [1]. Evidence shows that 5–17% of the population in English-speaking countries [2] and 3–5% of the population in Japan [3] have developmental dyslexia.

In order to guarantee the right to equal access to books, knowledge and information for everyone including readers with print disabilities, it is essential to provide readers who have developmental dyslexia with an assistive environment. In this research, we focus on adjustments to typographic elements of written materials, especially typefaces, as a visual assistive tool for readers with dyslexia.

Several Latin typefaces were recently created for dyslexic readers. Studies indicate that typefaces have significant positive impacts on readers with dyslexia in countries using the Latin alphabet [4]. With specially designed typefaces, readers with dyslexia are able to read with fewer errors [5], [6] or they simply prefer the specially designed typefaces compared to standard typefaces [7]. A recent study indicates that typefaces also affect readers with dyslexia in Japan [8]. The fact implies that Japanese typefaces designed for dyslexic readers would also be effective.

1.2 Problems

Japanese typefaces for readers with dyslexia have not been created so far mainly because: (1) the characteristics of typefaces (both Latin and Japanese) for dyslexic readers have not been clarified, (2) Japanese typefaces contain a large number of complicated characters, and (3) to create a typeface that fits everyone with dyslexia is not easy.

1.3 Research Objectives

In this research, we aim to solve the first problem by (i) clarifying the characteristics of Latin typefaces for readers with dyslexia and (ii) mapping them to Japanese typefaces to define the requirements for Japanese typefaces for readers with dyslexia, and to solve the second problem by (iii) creating a Japanese typeface for readers with dyslexia by programmatically manipulating glyphs of an open source typeface. This research, thus, consists of the following three studies:

Study 1 Clarifying the characteristics of Latin typefaces for readers with dyslexia,

*shushinjo@p.u-tokyo.ac.jp

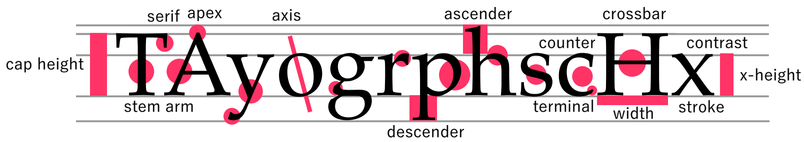

Figure 1: Elements of Latin Typefaces

Study 2 Defining the requirements for Japanese typefaces for readers with dyslexia by mapping the characteristics extracted in Study 1 to Japanese typefaces, and

Study 3 Creating a Japanese typeface for readers with dyslexia based on the requirements defined in Study 2 and evaluating the typeface.

We intend to solve the third problem by developing a typeface customization system which will be our future task.

2 Study 1: Characteristics of Latin Typefaces for Readers with Dyslexia

2.1 Methods

Since a typeface is the visual design of the letterforms [9], its function related to readability—the ease in reading text without strain or difficulty [10]—and legibility—the ease in distinguishing one letter from another [10]—result from its visual characteristics.

Thus, the Latin typeface characteristics more readable and legible for readers with dyslexia can be extracted by describing and comparing the visual features of typefaces designed for readers with dyslexia to those of standard typefaces that are less readable and legible for readers with dyslexia. Since visual features of typefaces exist as features of their graphic elements [11], comparing characteristics of typefaces means comparing the graphic elements of typefaces.

From over 40 elements of typefaces listed in Koizumi [11], Kobayashi [12], Middendorp [13], and Beier [14], we selected 15 core elements common to all the four. These elements are shown in Fig. 1.

In order to describe the characteristics of typefaces, we adopted three methods: (i) measuring the elements related to size of the glyphs, (ii) calculating the PANOSE values—PANOSE is "a system for describing characteristics of Latin fonts that is based on calculable quantities: dimensions, angles, shapes, etc." [15]—of typefaces by measuring the elements related to details of the glyphs, and (iii) visually comparing details of the elements related to identifying similar letterforms. These were selected based on the existing work [15]–[17] to extract the characteristics of typefaces both objectively and subjectively. The methods will be explained in detail at the workshop.

2.2 Materials

Two groups of typefaces were chosen: dyslexia typefaces and standard typefaces. We selected Dyslexie, Lexie Readable, and OpenDyslexic as dyslexia typefaces because they are widely used and have been evaluated in several studies; we selected Arial, Calibri, Century Gothic, Comic Sans, Trebuchet, and Verdana as standard typefaces, as they are recommended by the British Dyslexia Association [18]. These typefaces are shown in Fig. 2.

2.3 Results

The result of measuring the elements related to size of the glyphs is shown in Fig. 3, in which *c-height*, *u-width*, and *l-width* stand for *cap height*, *uppercase width*, and *lowercase width*. The detailed data of

Dyslexie	Arial	Comic Sans
Lexie Readable	Calibri	Trebuchet
OpenDyslexic	Century Gothic	Verdana

Figure 2: Dyslexia Typefaces and Standard Typefaces

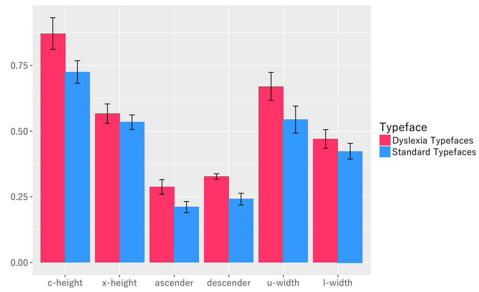

Figure 3: Average Size of Glyphs of Dyslexia Typefaces and Standard Typefaces

results of all the three methods will be shown at the workshop.

From the analysis conducted in Study 1, we extracted the following characteristics of Latin typefaces designed for readers with dyslexia.

1. Letters are larger than standard letters in the same font size,
2. Extremely tall cap height,
3. Larger gap between cap height and x-height,
4. Rounded sans serif typefaces,
5. Bolder strokes,
6. Larger height/width ratio,
7. Contrast in stroke width,
8. As for characters with similar letterforms:
    (a) Larger counters,
    (b) Manipulated shapes of letterforms,
    (c) Slanted or rotated to the opposite direction,
    (d) One character of a similar set replaced with an alternative letterform.

3 Study 2: Requirements for Japanese Typefaces for Readers with Dyslexia

3.1 Methods

In Study 2, the characteristics of Latin typefaces for readers with dyslexia are mapped to Japanese typefaces. Although Japanese writing systems are different from languages using the Latin alphabet, the character recognition process across the languages is similar [19]. Moreover, the visual symptoms of dyslexia such as letter reversals, distortion and blurring, and superimposition [20], [21], are similar between English and Japanese. It is therefore reasonable to assume that the general characteristics of Latin typefaces for readers with dyslexia can be mapped to Japanese typefaces.

In the first step of the mapping process, we listed the elements of Japanese typefaces based on Sato [22]–[26] and associated them with those of Latin typefaces according to their definitions. The elements of Japanese typefaces are shown in Fig. 4. In the next step, we reviewed research in the fields of graphic design as well as of psychology to determine the characters with similar forms in the Japanese writing system.

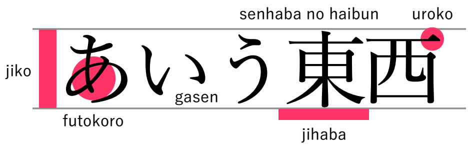

Figure 4: Elements of Japanese Typefaces

3.2 Results

Based on the research and discussion conducted in Study 2, the requirements for Japanese typefaces for readers with dyslexia are identified as follows.

1. Characters are larger than standard characters in the same font size,
2. Maru gothic (rounded sans serif) typefaces,
3. Bolder gasen (strokes),
4. Larger height/width ratio,
5. Contrast in the width of gasen (strokes),
6. As for hiragana and katakana characters with similar shapes:
   (a) Larger futokoro (counters),
   (b) Manipulated shapes of characters,
   (c) Slanted or rotated to the opposite direction,
   (d) One character of a similar set replaced with an alternative character.
7. As for kanji characters with similar shapes:
   (a) Larger futokoro (counters),
   (b) Manipulated shapes of characters,
   (c) Slanted or rotated to the opposite direction,
   (d) One character of a similar set replaced with an alternative character.
8. An option to frame the structure of kanji characters to illustrate radicals.

4 Study 3: Creation of a Japanese Typeface for Readers with Dyslexia

4.1 Methods

To create Japanese typefaces which fulfill the requirements defined in Study 2, we combined the programmatic method of manipulating glyphs of an existing typeface, the base font, with manual manipulation.

We selected Source Han Sans JP as the base font for the reason that it is an open source project of the CID-keyed OpenType font and its character collection is large enough for Japanese typefaces. Tools adopted during the process include RoboFont, Glyphs, and command line tools of AFDKO (Adobe Font Development Kit for OpenType).

We named the typeface created in this research *LiS Font*. It contains 2778 characters of hiragana, katakana, and kanji.

Two variations of *LiS Font* are presented in this paper: *LiS Font walnut* fulfills the requirement **1**–**4**, and **6**; *LiS Font cashew* fulfills the desideratum **1**–**6**. Both of them contain two versions—version A and B: version A stands for the kanji characters without additional framing lines implicating their structures while version B stands for the kanji characters with those additional framing lines, which means the requirement **8** is applied.

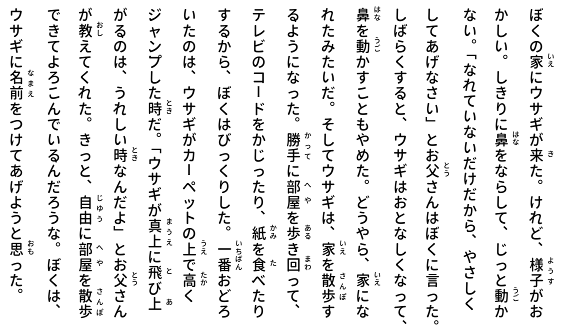

Figure 5: *LiS Font walnut A* in Use

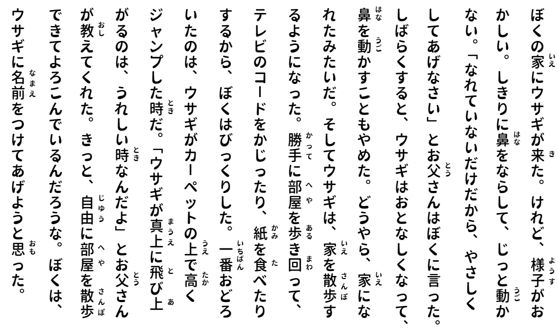

Figure 6: *LiS Font cashew A* in Use

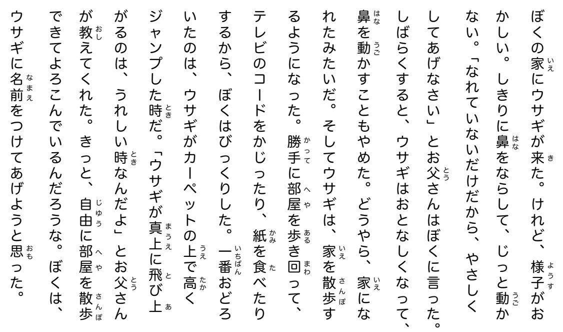

Figure 7: Standard Japanese Maru Gothic in Use

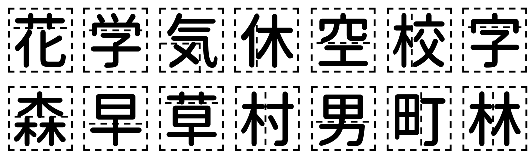

Figure 8: Kanji Characters with Additional Lines

4.2 Results

LiS Font walnut A in use with the text is demonstrated in Fig. 5. In *LiS Font cashew A*, the requirement **5** was applied on the basis of *LiS Font walnut A*. The *LiS Font cashew A* in use is shown in Fig. 6.

In *LiS Font walnut B* and *LiS Font cashew B*, the requirement **8** was applied on the basis of either *LiS Font walnut A* or *LiS Font cashew A*. Fourteen kanji characters to which the requirement **8** has been applied are shown in Fig. 8. Since the requirement **5** was only applied to kana characters, *LiS Font walnut B* and *LiS Font cashew B* share the kanji characters.

The evaluation concerning readability and legibility of *LiS Font* is currently being conducted.

5 Future Work

As is noted in Section 1, we intend to develop a Japanese typeface customisation system for readers with dyslexia in order to provide more personalized assistance. This system will be a GUI application which runs in modern browsers and enable users to change glyph shapes by adjusting sliders.

After reviewing 35 systems of parametric font creation [27], it is established that stroke-font-based systems such as METAFONT [28], instead of outline-font-based systems, are more suitable for typeface customisation. When developing a typeface customisation system in this research, therefore, we plan to select a collection of data including strokes of Japanese characters. At the moment, KanjiVG project [29], a project which describes strokes and stroke orders of Japanese characters in vectorial data, seems to fit our purpose. The first attempts of converting vectorial data of KanjiVG to glyph outlines automatically by scripts went well as shown in Fig. 9.

We intend to further explore methods of developing typeface customisation system based on stroke fonts and extend the typeface customisation system to cover other languages especially Asian languages.

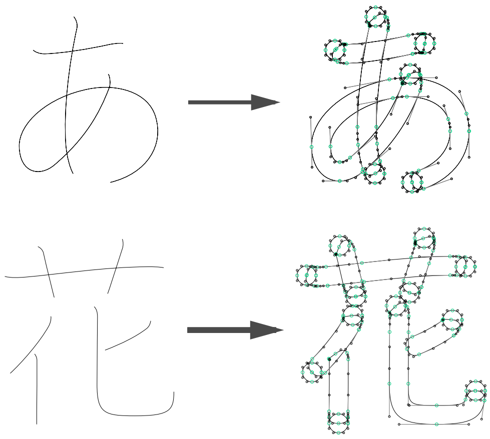

Figure 9: Converting Strokes to Outlines

Acknowledgement

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