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Theme I

NATURE AND DESIGN

Universal Design Fonts: Functional and Aesthetic Aspects

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Abstract

This study aimed to investigate common problems and future directions of Japanese universal design (UD) fonts. We share examples of UD fonts from 2006 to the present time. In Japan, awareness of UD is broad and far-reaching in every field of design, including product design, architectural design, and typography. In the area of UD, the concept of inclusive typeface design has attracted much attention with regards to making fonts legible for as many people as possible, especially for people with impaired vision. A notable example of UD based on scientific evidence was developed by Iwata Corporation in association with Panasonic Corporation. Morisawa Inc. and Fontworks Inc. also produced a series of Japanese UD fonts. However, a frequently discussed problem is that enhancing functional factors, such as legibility and readability, may reduce aesthetic attributes through their unnatural form. UD font is an artificial design object that emphasizes functional factors. However, it is acknowledged that natural form is also an important evaluation factor. By drawing on both scientific findings, and designers' experiences, this paper focuses on UD fonts, considering associated challenges and future directions related to functional and aesthetic aspects of the fonts.

Keywords: *Universal design font; functional aspects; aesthetic aspects; design features*

1. Introduction

In Japan, awareness of Universal Design (UD) is broad and reaches into every field of design, such as product design, architectural design, and also typography. In the area of UD, the concepts of inclusive typeface design have attracted attention through attempts to make an easy-to-read font for as many people as possible, especially for those with low vision.

Japanese UD fonts were initiated by Iwata Corporation in association with Panasonic Corporation based on scientific evidence, and provide excellent examples of UD. Morisawa Inc. also produced a series of Japanese UD fonts, which were shown to have high performance with regards to blur tolerance.¹ NEC Corporation designed 'FA UD Gothic' Font and tested its readability, visibility, legibility, and display adequacy. These are examples of a new context in which typeface legibility is investigated through cooperation between designers and researchers. Typefaces are used as test material and experiments are conducted that evaluate them using the methods of psychophysical scientists.

In these evaluation reports, readability, visibility, and legibility have been treated in almost the same way, but aesthetics have not been treated as a positive evaluation item. One of the problems often pointed out with UD fonts is that when trying to improve legibility, aesthetics may be reduced. To address this problem, it would be important to consider the relationship of function with the feature of the character design. By drawing on scientific findings and designers' experiences, this paper will focus on UD fonts, considering associated problems and future

directions by looking into functional and aesthetic aspects.

2. Japanese Universal Design fonts

Table 1 summarizes previous research which focused on both design and test capability of UD fonts. These studies demonstrate that for optimally improved functionality characters benefit from relatively large character area, open counters, large dakuten and handakuten, and stroke width. Research also indicates that eliminating the decoration at the start of strokes could improve visibility of UD fonts (Figure 1).

Author	Designed capability	Font design concepts
Washinosu(2) Iwata UD Gothic	Legibility Visibility Aesthetic	Legibility: large gap between the dakuten and the strokes, open counters, consider misread character groups Visibility: open counters, eliminate the decoration at the end of strokes Aesthetic: change katakana characters' height, and alphabets' x-height
Nakano <i>et al.</i> (3,4,5) Type Bank UD Gothic	Legibility Visibility Readability	Legibility: consider misread character groups large dakuten and handakuten
Miyazaki <i>et al.</i> (6) LIM Corporation LIM Uni-Type	Legibility Readability Favorable impression	Legibility: large dakuten, open counters Readability: large character areas
Hakamada <i>et al.</i> (7) NEC Corporation FA UD Gothic	Legibility Visibility Readability Display adequacy	Legibility: consider misread character groups Visibility: large character areas(kanji&kana), open counters, stroke width Readability: large kana character areas Display adequacy: change the curve lines to straight lines

Table 1: Summary of previous studies. For (2)-(7), see Notes 2-7.

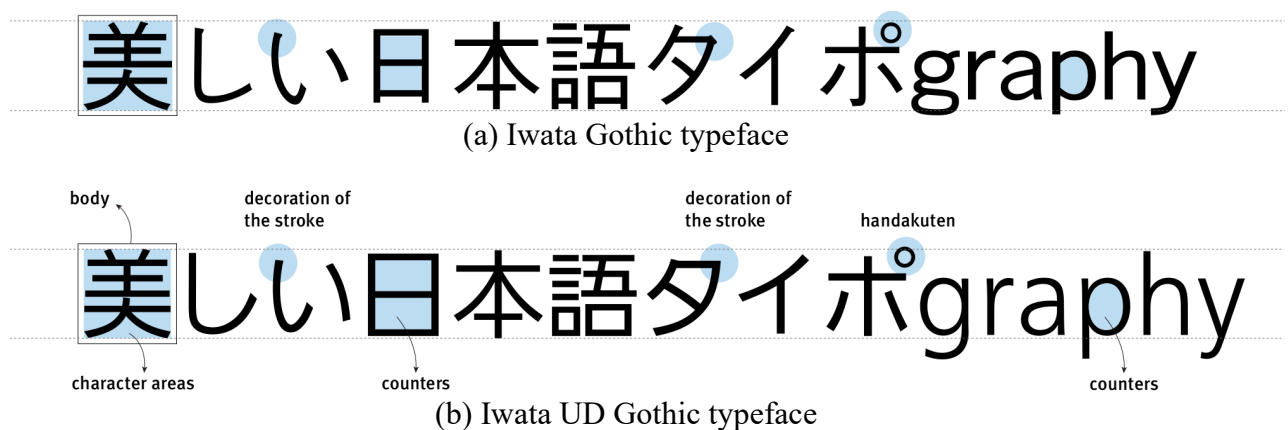


Figure 1: Matters to consider when designing UD font: the character areas, the size of dakuten and handakuten, the design of the decoration of strokes, the stroke width, the counters, and the size of the hiragana and katakana character height.

1) Legibility

Legibility refers to the ability to distinguish single typographic characters. During the development process of UD fonts, several font vendors investigated character design, such as dakuten, handakuten, the angle of stroke, and counter. They reexamined the design concept of these elements to avoid misreading and improve legibility.

Iwata Corporation noted that the gap between the dakuten and the strokes aid legibility. Most font vendors such as Typebank and Morisawa Corporation insist on this design concept, and apply this brief to their UD font design. A similar solution was applied in LIM Uni-Type. Designers consider that large dakuten assist legibility. They changed the characters' form of the new UD font aiming to create a larger space for the dakuten and handakuten, including the gap between the dakuten or handakuten and stroke. Then, researchers investigated the legibility of the hiragana and katakana characters to check the validity of this design concept. The results verified the high legibility of this new UD font.

To avoid misreading, Iwata Corporation considered commonly misread character groups such as '6' and '9'. They changed the angle of the stroke of some kana and alphanumeric characters to avoid misreading. Similarly, Typebank and NEC Corporation also emphasized the need to distinguish between similar character pairs to improve legibility.

Counters have frequently been overlooked in UD font studies. A concept of UD font design is that the larger the counters, the larger the font is perceived to be. Hence large counters improve legibility within the limited horizontal width. During the development process of Iwata UD Gothic, designers looked into kana and alphanumeric characters. They emphasized the importance of clear and open counters, avoiding clogged counters and therefore, more ambiguous letter shapes.

2) Visibility

Iwata and NEC Corporation focused on font visibility in the process of font design. In the design guide for the Iwata UD Gothic, researchers described visibility as how easy the individual character itself can be seen. Visibility is greatly affected by the counters, character areas, and stroke thickness. Character areas and counters generally improve font visibility and legibility. It may seem logical to assume that the larger the character area, the easier it is to see. Based on the results of evaluation tests, Iwata Corporation proposed and implemented design principles in their UD font, including an enlarged character area. A similar solution was applied in FAUD Gothic by NEC Corporation. They noted that large designed character areas, including counters, make characters easy to see, thereby improving visibility.

Stroke thickness has also been considered as one of the font features that may affect visibility. During the development process of Iwata UD Gothic, the researcher compared three weights (medium, regular, and light) of this font with this method. The result showed that the medium weight is more visible than the other weights.

3) Readability

The meaning of readability is how easy the font is to read in a single paragraph of text. Lim-Type considered current use of font in our daily life. Their results led to establishment of the design principle of enlarging the kana area approximating kanji characters to improve readability.

Verification experiments have been conducted to evaluate this design concept. Researchers made a psychological impression evaluation by using short Japanese sentences composed of kana and kanji characters as the stimuli. The results confirmed the high readability of the UD font, especially in small-sized characters.

N.Yang *et al.*⁸ studied the effect of font visual attributes on readability. An analysis of the correlation between the readability test results and visual attributes showed that stroke density is

a significant character attribute affecting the readability evaluation of UD fonts. Results showed that the high stroke density improves the readability for senior participants.

4) Aesthetics

As noted, the development progress of UD fonts has focused on functional aspects, like legibility, visibility, and readability rather than on aesthetic parts. These aspects are not necessarily compatible, a point raised by A. Mizuno in a report on the development history of Iwata UD font.⁹ “Better visibility can be obtained by designing a relatively large character area, but it will lead to a problem that the space between two specific characters becomes narrow. Based on years of experience, this interference could make the character harder to read.”

This phenomenon is most evident in the aesthetic evaluation study.¹⁰ An analysis of the correlation between the aesthetic evaluation test results and visual attributes showed that character areas, especially kana character areas and counters were significant factors that affected the aesthetic evaluation for the Gothic typeface used in the body text. The fonts with small character areas and counters were highly acclaimed. This result conflicted with the design concept of a legible and visible font.

The impression of aesthetics may be related to the familiarity of the participants, and the reason for the low evaluation could be that participants are unaccustomed to the UD font shape. In another investigation, the researcher conducted the psychological favorable impression experiment to look into LIM Uni-Type. Findings showed that the favorable impression evaluation of LIM Uni-Type was lower than regular fonts. However, by repeating presentation of LIM Uni-Type, the favorability tended to increase.

The design aspect analysis of UD fonts shows that their design is reasonable and follows its functional aims. However, it can be seen that the main design points of various functions are not the same. For example, larger character area can improve the visibility of the font, but will reduce readability and aesthetics. It is challenging to meet all functional requirements through one kind of design. UD font cannot satisfy all functional requirements at the same time, although it is a specialized typeface that can meet some specific functions.

By comparing the design features of UD fonts, it can be seen that designers and researchers emphasized improvement of functional aspects of the fonts by changing the font design only. They did not clarify the design standards, so it remains difficult to choose an approach to designing these UD fonts. For example, the size of the character area affects the visibility, but there is no research offering a specific range of character area. There are no clear design criteria given for such problems.

3. Empirical studies of Japanese typography

‘Universal’ is the natural feature that typography should have and which attracts great attention now. When a typeface designer pursues the beauty of shape, it is natural to consider readability at the same time. This is not a novel concern of the 21st century. However, compared to western countries, there is limited empirical data on readability or legibility in Japan. Experimental research has been conducted in this area since the 1960s. Nagano *et al.*¹¹ defined readability in terms of font that could be read quickly, was easy to understand, resulted in less fatigue, and had a beautiful appearance. They studied the influence of character form on the readability of printing, and clarified that the form of printing-type most easy to read is printed horizontally, in oblong, square or rectangular forms.

In another investigation, I. Yoroizawa¹² made a psychological impression evaluation of readability using the semantic differential method. Twenty-seven types of stimuli varying in font type, character shape, and line width were used. Findings demonstrated that human emotions are

influenced by the relationship between the different character forms.

Since the 1990s, awareness of readability and visibility has moved towards the elderly and people with low vision. There is a focus on the needs of these populations in terms of reading cognition and improvement processes. M. Funakawa and K. Oda¹³ used a low-pass filtering method for evaluating visibility. The results showed that for people with unimpaired vision, fonts with clear open counters have high visibility. Stroke width was also found to influence visibility evaluation. When the font has thicker strokes, it becomes more difficult to see. This phenomenon was further evident in the data of the test study carried out by Funakawa.¹⁴ He regarded minimum visual acuity and minimum time to read character images as indicators of visibility. The character areas, stroke width, stroke contrast, and background brightness effect on legibility were measured and shown quantitatively.

4. Empirical studies of western typography

Compared with Japanese, western typography has been the subject of much objective evaluation and research on readability and legibility. This work has been supported by the contributions of interdisciplinary experts such as psychologists and cognitive scientists dating back many years.

The question of how to design a font that is easy to read has been addressed for over a hundred years. In the first half of the twentieth century, many experimental studies of readability and legibility were conducted. From the late '60s, attention to these issues moved towards interest in the cognitive process of reading to improve reading problems.

Comprehensive research using behavioral science methods was carried out by Tinker.¹⁵ He evaluated visibility, legibility, and readability using more than ten types of fonts varying in character size, character spacing, line length, and line spacing. The results showed that standard Roman is more readable than Italics. Moreover, lowercase letters are easier to read than uppercase ones. In terms of stroke, sans serif fonts with certain stroke thickness, and thick stroke fonts are more comfortable to read. He also noted that open counters might aid font readability.

The ultimate pursuit of easy-to-read font design was the study by Ardit.¹⁶ He adjusted the stroke width, serif, x-height, and inter-letter spacing of the test font, then measured the critical print size and reading speed of the test font. He found the inter-letter space was the significant character attribute which affects readability. However, compared with Times New Roman, the readability of this new font was low.

Only a small component of Japanese and western typography has been presented here. The history of functional aspects and evaluation of font performance by scientists and psychologists has been considered for many years and the results of functional investigations have steadily accumulated. Although changing over the years in terms of display situations, findings from quantitative research reveal many commonalities in terms of readability, visibility, and legibility. From the past to the present, designers have always searched for functional fonts, and many attempts have been made to design such fonts.

'Frutiger' is a typical example of a functional font. In 1968, Adrian Frutiger developed a highly visible font for the signage at Charles de Gaulle Airport. This font could not be misread even from a distance. The ascending and descending lines were emphasized for easy recognition, and the difference in thickness between the horizontal and vertical strokes was reduced. The thickness and size of the characters were determined based on a legibility experiment. The typeface was later reworked and extended to be released under the name 'Frutiger'. After that, a series of typefaces were produced with reference to Frutiger. As a derived font, MetaDesign released the font 'FF Transit' based on 'Frutiger' in 1997. Another notable example is 'Myriad' produced by Adobe Systems.

This review of empirical studies of typography shows that functional aspects are not a new

concern regarding UD fonts in the 21st century. Type designers and researchers have posed these questions for a long time. Western typography has many specialized functional fonts, however, unlike Japanese typography unique names have not been assigned to the fonts to emphasize functionality.

5. Summary

In recent years, 'Universal' fonts have become an important topic. Until now, a range of UD fonts have been produced including UD gothic font, UD rounded-gothic font, and UD Mincho font, together ensuring UD fonts have become established as a category. These fonts focus on being easy to see and read. The concept of UD, a product plan that can be used by as many people as possible, is incorporated into the typeface design, making it accessible for all people, including those with visual disabilities such as amblyopia and the elderly. The design features of the UD fonts have been verified in evaluation experiments of the functional aspects of the fonts. While UD fonts are highly valued, the focus on improved legibility has resulted in reduced aesthetics. Our review showed that design features that satisfy each functional aspect of the UD fonts are not always the same.

The Japanese UD font was initially designed for documentation on machines, and more specifically for short sentences in horizontal typesetting. This indicates how UD fonts were developed for functional purposes rather than aesthetic needs. However, the name UD has led to misunderstandings that this kind of font can be used anywhere. For example, using it in a long article, where readers would feel that the font has poor aesthetics and is not easy to read.

As the scope of use expands and demand for new categories of Japanese typography increases in future, there are likely to be many more UD fonts specialized for various applications. These fonts will need to be considered in terms of functional performance and in balance with aesthetic aspects. These issues are challenging but essential for consideration.

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