MORISAWA FONT

Report on Comparative Research on Legibility and Readability of Morisawa UD Fonts

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Purpose and Background

Since the release of universal design (UD) fonts in November 2009, Morisawa has received many requests from customers to provide the scientific evidence of the effectiveness of UD fonts. Conventional fonts are usually designed for users with normal vision of the language for which fonts are developed, and their major functions are determined mainly by type designers. In contrast, UD fonts are intended for use by people with low vision whose visual functions are impaired due to such reasons as illness, accidents, or aging, as well as by people with difficulty in focusing on the near object because of aging (in alignment with the universal design concept defined in the UN Convention on the Rights of Persons with Disabilities adopted in December 2006). Against this background, we have decided to study the benefits of UD fonts—legible characters, efficient in reading, and effective for low vision—by comparing UD fonts with their conventional versions. For this purpose, Morisawa has commissioned Yasushi Nakano, professor of psychology at Keio University, to conduct a comparative study that focused on UD fonts' readability (reading efficiency) and legibility from among four major font functions of readability, legibility, visual attention, and impression.

Summary of the Comparative Research

It is obvious that a font is designed and developed with readability and legibility in mind besides visual attention and impression. As described in the Purpose and Background above, the study compared UD fonts with their conventional versions especially for their readability and legibility. The overall comparison indicated that when taking character size into consideration, UD fonts were more legible and efficient in reading than conventional fonts for people with visual impairment or difficulty.

UD Reimin in particular, in addition to its superiority in the vertical setting inherent in Ming-cho type, it also exceled in readability and legibility in the horizontal setting.
A readability test was also conducted for UD Shin Go Condensed which is scheduled to be released in autumn 2013. The test using a peripheral vision loss simulator resulted that narrower fonts achieved better readability for people with restricted visual field.

A. Verification of Morisawa UD Fonts Readability

Purpose: To assess reading efficiency and readability in text using MNREAD-J reading acuity charts

Verification results

As a result of scoring all studied fonts in descending order by category, under both high and low visual acuity conditions, UD Reimin (for vertical use), Ryumin (for vertical use), UD Reimin (for horizontal use), Company A's UD font (for vertical use), and Ryumin (for horizontal use) achieved higher reading efficiency than other fonts. (Table 1 shows the top five fonts for low visual acuity.)

Verification conditions

The test was conducted for the three categories of reading acuity*, critical character size*, and the maximum reading speed* for Ming-cho (vertical), Ming-cho (horizontal), sans (vertical), and condensed (horizontal).
Low visual acuity refers to the average visual acuity of 0.159, and high visual acuity with the average visual acuity of 0.271 (visual acuity conditions slightly vary depending on fonts). High and low visual acuity conditions were simulated using a ground-glass diffuser, and each condition was assessed by adjusting the position of the diffuser.

Fonts compared

UD Reimin (vertical) / Ryumin (vertical) / Company A's UD font (vertical) / UD Reimin (horizontal) / Ryumin (horizontal) / Company A's UD font (horizontal) / Shin Go (vertical) / UD Shin Go (vertical) / Gothic Medium BBB (vertical)

Evaluation method

For comparing the fonts, sample charts were created based on the MNREAD-J reading acuity charts, the Japanese version of the MNREAD reading acuity charts* developed by the University of Minnesota. An environment was also created using a ground-glass diffuser to simulate high and low visual acuity. A chart was placed 30 cm away from the eyes of a participant, and the participant was asked to read each sentence aloud as fast and accurately as possible. Seven types of texts were prepared for charts and used randomly by font and participant. The test was conducted in a room with no outside light interference so that the charts were evenly illuminated with an average light intensity of 636.5 lux.

* Notes:

Reading acuity:
The smallest print that can be read. Measured in logMAR (logarithm of the minimum angle of resolution: character size expressed visually and transformed logarithmically). Lower values indicate better readability.

Critical character size:
The smallest print that supports the maximum reading speed. Measured in logMAR. Lower values indicate better readability.

Maximum reading speed:
The reading speed when performance is not limited by print size. Measured in the number of letters read correctly per minute. Higher value indicate better readability.

MNREAD reading acuity charts:
The MNREAD reading acuity charts were developed by Professor Gordon E. Legge at the University of Minnesota, and the Japanese version (MNREAD-J) was created by Professor Koichi Oda at Tokyo Women's Christian University. Charts were organized under the unified conditions including sentence difficulty and line length. Specific conditions for MNREAD-J are as follows: (1) A three-line text of 10 characters per line, 30 characters in total; (2) up to eight kanji per line; (3) no words broken at line ends; (4) limited word length; (5) limited number of voiced sound marks; and (6) no duplicate words.

Table 1. Comparison of Readability: Top 5 Fonts by Category: For Low Visual Acuity

Reading acuity	LogMAR	Critical character size	LogMAR	Maximum reading speed	MRS (character/min.)
UD Reimin (vertical)	0.547	UD Reimin (vertical)	0.75	UD Reimin (vertical)	385.883
Ryumin (vertical)	0.551	Ryumin (vertical)	0.76	Ryumin (vertical)	382.002
UD Reimin (horizontal)	0.551	UD Reimin (horizontal)	0.77	UD Reimin (horizontal)	380.581
Company A's UD (vertical)	0.557	Company A's UD (vertical)	0.79	Company A's UD (vertical)	372.749
Ryumin (horizontal)	0.558	Ryumin (horizontal)	0.8	Ryumin (horizontal)	370.152

B. Verification of Morisawa UD Fonts Legibility

Purpose: To measure how easily an individual character is recognized

Verification results

As a result of scoring all studied fonts in descending order by category, UD Reimin was the most legible for high visual acuity, followed by UD Shin Go, Shin Go, Company A's UD font, Ryumin, and Company B's sans. For low visual acuity, UD Reimin was the most legible, followed by Company A's UD font, UD Shin Go, Shin Go, Ryumin, and Company B's sans.

In general, the recognition threshold* value of each character type of the studied UD fonts (UD Reimin, UD Shin Go, and Company A's UD font) were higher than other fonts for both high and low visual acuity. For low vision in particular, UD Reimin scored the highest among the fonts compared, proving its excellent legibility.

* Note:

Recognition threshold: Character size measured in point.

Verification conditions

Characters of the fonts were presented one by one (see the character list below), measuring the recognition threshold and reaction time.

Evaluation method

As with the readability test, high and low visual acuity conditions were simulated using a ground-glass diffuser, and the recognition threshold (the smallest print that can be read accurately) and reaction time were measured by displaying one character at a time in the center of the computer screen.

Fonts compared

UD Shin Go / Shin Go / Company B's sans / UD Reimin / Ryumin / Company A's UD font / UD Shin Maru Go / Maru Today / Soft Gothic / UD Shin Go NT / Gothic Medium BBB / Company C's UD font

Number of character types tested

10 numerals / 25 Latin small letters / 25 Latin capital letters / 25 hiragana / 25 katakana / 65 kanji

Table 2. Legibility Test Results: Top 6 Fonts by Category: For Low Visual Acuity

Numerals	Recognition threshold	Small letters	Recognition threshold	Capital letters	Recognition threshold
Shin Go	15.33	Company A's UD font	18.28	Shin Go	15.2
UD Shin Go	15.52	UD Reimin	18.3	UD Reimin	15.28
UD Reimin	15.59	UD Shin Go	18.32	UD Shin Go	15.38
Company A's UD font	16.24	Shin Go	19.76	Company A's UD font	15.8
Ryumin	16.7	Ryumin	20.54	Ryumin	16.18
Company B's sans	19.18	Company B's sans	22.72	Company B's sans	18.4

Hiragana	Recognition threshold	Katakana	Recognition threshold	Kanji	Recognition threshold
UD Reimin	16.73333	Company A's UD font	17.41667	UD Reimin	18.66
UD Shin Go	16.86667	UD Shin Go	17.73333	Company A's UD font	18.98
Company A's UD font	16.9	UD Reimin	17.75	Ryumin	19.32
Ryumin	16.91667	Shin Go	18.3	UD Shin Go	20.34
Company B's sans	18.15	Ryumin	18.71667	Company B's sans	20.72
Shin Go	18.21667	Company B's sans	19.61667	Shin Go	20.82

C. Verification of UD Shin Go Condensed* Readability

Verification results

For high visual acuity, reading acuity and critical character size showed a statistically significant difference in the order of UD Shin Go Condensed 100, 70, and 50, while no significant difference in the maximum reading speed. For low visual acuity, while no significant statistical difference was observed in reading acuity, critical character size and the maximum reading speed showed a significant difference in the order of UD Shin Go Condensed 100, 70, and 50.

Evaluation method

Reading acuity, critical character size, and the maximum reading speed were measured using charts for high and low visual acuity.

Fonts compared

UD Shin Go Condensed 100 / UD Shin Go Condensed 70 / UD Shin Go Condensed 50

* Note:

Condensed font:
A narrower version of the standard font, allowing packing more characters into a line in the horizontal setting.

D. Verification of UD Shin Go Condensed Legibility

Verification results

The statistics showed that a difference in legibility by degree of condensation was observed only for hiragana. The following fonts showed a significant difference in response time.

Numerals: UD Shin Go Condensed 50 was easier to recognize.
Capitals: UD Shin Go Condensed 70 and 50 were more legible than UD Shin Go Condensed 100.

Evaluation method

A method to measure the recognition threshold (the smallest character that can be read accurately) and reaction time was used.

E. Verification of UD Shin Go Condensed Readability Using Peripheral Field Loss Simulator

Verification results -1

Since no difference was observed in the maximum reading speed, reading efficiency is unaffected if the character size is well readable.

Evaluation method-1

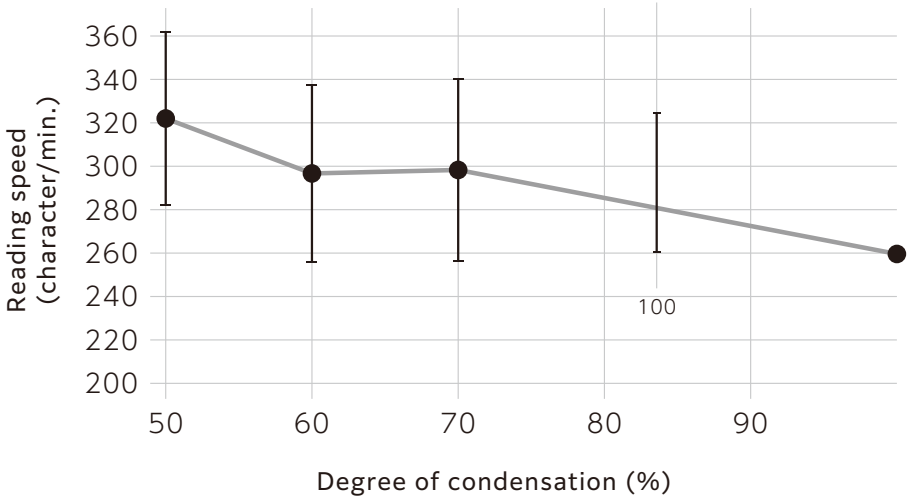
Using MNREAD-J reading acuity charts, four types of fonts (UD Shin Go Condensed 100, 70, 60, and 50) were tested at the two levels (three and five degrees) of peripheral field loss.

Verification results -2

If the character size is large enough, narrower condensed fonts are more readable for people with peripheral field loss.

Evaluation method -2

Comparison test using long sentences



Reference

In the post-test interviews about the preference of condensed fonts, seven out of ten participants responded that Condensed 50 was the most readable, while the remaining three answered that Condensed 60 was the best. One of the main reasons was that their narrower width allowed readers to catch the next character more easily.

Number of participants

1. Preliminary test	Readability test: 8	
	Legibility test: 8	Total: 16
2. Main test	Readability test: 88	
	Legibility test: 110	Total: 198

Number of trials for each test (per participant)

1. Visual acuity
   ・120 times × 3 visual conditions = 360 times

2. Refraction test
   ・1 time for each eye = 2 times
   ・For participants with glasses, 1 time for each eye = 2 times
   Total: 4 times

3. Readability test
   ・Trial: Reading aloud of 30 characters: 19 times
   (Number of characters read: 570)
   ・Reading aloud of 30 characters: 19 times × 3 fonts× 2 visual conditions = 114 times
   (Number of characters read: 3,420)
   Total: 133 times (Number of characters read: 3,990)

4. Legibility test
   ・Trials: Numerals 10 times + Hiragana 12 times + Katakana 12 times + Small letters 10 times + Capital letters 10 times + Kanji 10 times = 64 times
   ・Numerals: 10 times × 3 fonts × 2 visual conditions = 60 times
   ・Hiragana: 12 times × 3 fonts × 2 visual conditions = 72 times
   ・Katakana: 12 times × 3 fonts × 2 visual conditions = 72 times
   ・Small letters: 10 times × 3 fonts × 2 visual conditions = 60 times
   ・Capital letters: 10 times × 3 fonts × 2 visual conditions = 60 times
   ・Kanji: 10 times × 3 fonts × 2 visual conditions = 60 times
   Total: 448 times

Reference photos

Photo 1: MNREAD-J reading acuity charts

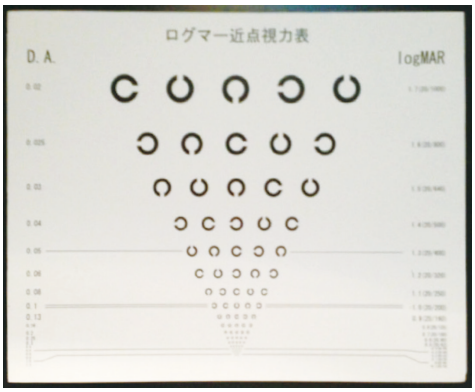


Photo 2: LogMAR vision chart

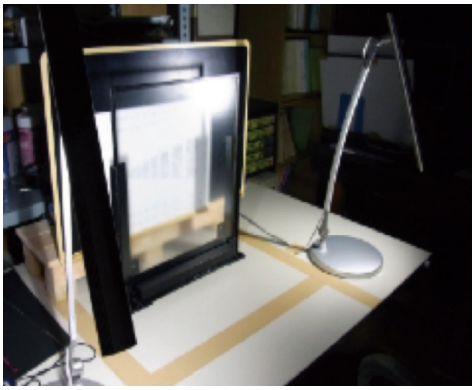


Photo 3: Test equipment


Photo 4: Peripheral field loss simulator