MORISAWA FONT

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

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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, accident, or aging, as well as by people with difficulty in focusing on near objects 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). Morisawa commissioned Prof. Yasushi Nakano of the Keio University Psychology Laboratory to verify whether UD fonts are superior to others for these readers. Prof. Nakano compared UD fonts against ordinary fonts on three points of the UD font concept: 1) legibility of characters, 2) high reading efficiency, and 3) strong suitability for people with low vision. According to his verification report entitled “Report on Comparative Research on Legibility and Readability of Morisawa UD Fonts” (2013), characters in UD fonts are easier to distinguish than those in ordinary fonts and readers can more efficiently read information, etc.

More recently, however, the prevalence of tablets and smartphones has given people more opportunities to encounter characters through digital devices. This made it necessary to clarify how easily characters displayed on such devices can be viewed and read. Morisawa commissioned Prof. Yasushi Nakano to verify this.

Summary of the Comparative Research

Simulating the conditions of low vision, this research verified (1) the advantage of UD fonts on digital devices in terms of font legibility (ease of viewing and distinguishing) and

readability (ease of reading) and (2) whether the same results could be derived for people with low vision.

(1) Using an overall ranking method, Prof. Nakano's research indicated that in vertical writing, Morisawa UD Shin Maru Go and Morisawa UD Shin Go provided excellent readability. In horizontal writing, under all visual acuity conditions, Gothic fonts were superior. Specifically, UD Gothic was the best of them all. Particularly when cataract simulation goggles were used to simulate low vision, UD Shin Maru Go provided extremely good readability. By the paired comparison method, the results showed that UD Shin Maru Go was the easiest font to read in all tests, for both vertical and horizontal writing.

(2) Most of the participants chose UD Shin Maru Go as the easiest font to view, suggesting the superiority of UD fonts in terms of ease of viewing. These results are consistent with the results for people with normal vision.
The above shows that UD fonts are more readable than ordinary fonts even on digital devices.

Note: See the end of this paper for information on the full source.

A. Veification of Morisawa UD Font Legibility / Readability on Digital Devices (1) Overall Ranking Method

This verification test shows the superiority of UD fonts on digital devices.
Verification was conducted in two ways: (1) overall ranking method*1 and (2) paired comparison method. This page describes the results of the verification by (1) overall ranking method.

Verification results

In vertical writing, Morisawa UD Shin Maru Go provided the best readability, both in cases without low vision simulation and in cases of low vision simulation with cataract simulation goggles (Fig. 1 and Fig. 3). Morisawa UD Shin Go provided the best readability in cases where a blur filter was used to simulate low vision (Fig. 2). Under all visual acuity conditions, there was no statistically significant difference between UD Shin Maru Go and UD Shin Go. It means that these two have the same level of readability.
In horizontal writing, under all visual acuity conditions, Gothic fonts were superior. Specifically, UD Gothic was the best of them all. UD Shin Maru GO provided extremely good readability, particularly when cataract simulation goggles were used to simulate low vision.

Verification conditions

Device: Digital device (iPad Air)
Visual acuity conditions: (1) No low vision simulation (average visual acuity 1.04) / (2) Low vision simulation with a blur filter (average visual acuity 0.176) / (3) Low vision simulation with cataract simulation goggles (average visual acuity 0.212).

Evaluation method

Using a readability test machine and iPad Air, character readability was compared under the three conditions: (1) No low vision simulation / (2) Low vision simulation with a blur filter / (3) Low vision simulation with cataract simulation goggles.
The method of verification was to show participants the same text in the different fonts compared and ranked the fonts by readability. Eight fonts, which would then be compared in vertical typesetting and ten in horizontal typesetting.

Fonts compared

Vertical writing: UD Shin Go, UD Shin Maru Go, UD Reimin, Kyoukasho ICA, UD Gothic (Company D), Gothic (Company A), UD Maru Gothic (Company A), Mincho (Company A) (8 fonts total)
Horizontal writing: UD Shin Go, UD Shin Go Conde70, UD Shin Maru Go, UD Reimin, Kyoukasho ICA, UD Gothic (Company D), Gothic (Company A), UD Maru Gothic (Company A), Mincho (Company A), Condensed Gothic (Company E) (10 fonts total)

Note

*1 Overall ranking method

Verification by the overall ranking method used a set of 8 fonts in vertical writing and a set of 10 fonts in horizontal writing. Under the test plan, participants compared and ranked the fonts in each set and the results were analyzed. The statistical analysis was performed by analysis of variance (ANOVA4) and a one-way layout model of within-participants factors (taking differences between fonts as the standard). The significance level was set at 5% in all cases.

Fig. 1 Differences in character ease of viewing by font (1)

Visual acuity conditions: No low vision simulation

Vertical writing	Font name	Point
No. 1	UD Shin Maru Go	44
No. 2	UD Maru Gothic (Company A)	52
No. 3	UD Shin Go	54
No. 4	UD Gothic (Company D)	68
No. 5	Gothic (Company A)	68
No. 6	UD Reimin	75
No. 7	Mincho (Company A)	77
No. 8	Kyoukasho ICA	102

Horizontal writing	Font name	Point
No. 1	UD Maru Gothic (Company A)	53
No. 2	UD Shin Maru Go	55
No. 3	UD Shin Go	59
No. 4	UD Gothic (Company D)	64
No. 5	Gothic (Company A)	69
No. 6	UD Reimin	81
No. 7	Mincho (Company A)	88
No. 8	Kyoukasho ICA	104
No. 9	Condensed Gothic (Company E)	121
No. 10	UD Shin Go Conde70	131

Fig. 2 Differences in character ease of viewing by font (2)

Vision acuity conditions: Low vision simulation with a blur filter

Vertical writing	Font name	Point
No. 1	UD Shin Go	42.5
No. 2	UD Maru Gothic (Company A)	45.5
No. 3	UD Shin Maru Go	49.5
No. 4	UD Gothic (Company D)	57.5
No. 5	Gothic (Company A)	66
No. 6	Mincho (Company A)	83
No. 7	UD Reimin	96
No. 8	Kyoukasho ICA	100

Horizontal writing	Font name	Point
No. 1	UD Maru Gothic (Company A)	44
No. 2	UD Reimin	60.5
No. 3	Gothic (Company A)	62.5
No. 4	UD Shin Go	74
No. 5	UD Gothic (Company D)	75
No. 6	UD Shin Maru Go	78
No. 7	Kyoukasho ICA	87
No. 8	Mincho (Company A)	89
No. 9	Condensed Gothic (Company E)	124
No. 10	UD Shin Go Conde70	131

Fig. 3 Differences in character ease of viewing by font (3)

Vision acuity conditions: Low vision simulation with cataract simulation goggles

Vertical writing	Font name	Point
No. 1	UD Shin Maru Go	40
No. 2	UD Maru Gothic (Company A)	50
No. 3	Gothic (Company A)	55
No. 4	UD Shin Go	60
No. 5	Mincho (Company A)	66
No. 6	UD Reimin	81
No. 7	Kyoukasho ICA	92
No. 8	UD Gothic (Company D)	96

Horizontal writing	Font name	Point
No. 1	UD Shin Maru Go	28.5
No. 2	UD Shin Go	39.6
No. 3	UD Gothic (Company D)	51
No. 4	Gothic (Company A)	73
No. 5	UD Maru Gothic (Company A)	77
No. 6	Mincho (Company A)	94
No. 7	Condensed Gothic (Company E)	101.5
No. 8	UD Shin Go Conde70	112.5
No. 9	UD Reimin	123
No. 10	Kyoukasho ICA	125

B. Verification of Morisawa UD Fonts Legibility / Readability on Digital Devices (2) Paired Comparison Method

This verification test shows the superiority of UD fonts on digital devices. Verification was conducted in two ways: (1) overall ranking method and (2) paired comparison method. This page describes some parts*2 of the verification results by (2) paired comparison method.

Verification results

In the case of low vision simulation by a blur filter, UD Shin Maru Go was the best in all tests with both vertical and horizontal writing (Fig. 4).

Verification conditions

Device: Digital device (iPad Air)
Vision acuity conditions: Low vision simulation with a blur filter

Evaluation method

Using an iPad Air and under the conditions of low vision simulation with a blur filter, tests were conducted using a paired comparison program and the results were analyzed. During the test, the participants were asked repeatedly which of two fonts was easier to view. The test was repeated ten times. Five fonts were compared in vertical typesetting and five in horizontal typesetting. UD Shin Go was eliminated from the list of fonts compared, since the test, such as the overall ranking method, showed no difference between UD Shin Go and UD Shin Maru Go.

Fonts compared

Vertical and horizontal writing: UD Shin Maru Go, UD Reimin, UD Gothic (Company D), Gothic (Company A), Mincho (Company A) (5 fonts total)

Note

*2 Verification by paired comparison method

With the paired comparison method, two of the fonts to be compared were chosen at random and shown together to the participant, who was asked to pick the better one in each combination.
There were three requirements to the test to demonstrate the superiority of UD fonts: confirmation of whether the results of the overall ranking method and paired comparison method differ, verification of the combinations of fonts that are difficult to distinguish, and detection of the optimal character size to distinguish characters. The paired comparison verification of the fonts was performed after these three requirements were obtained. The verification showed that the results of the paired comparisons were more detailed than those of the overall ranking method.

Fig. 4 Test results by paired comparison method

Vertical writing	Font name	Scale value
No. 1	UD Shin Maru Go	0.900
No. 2	Gothic (Company A)	0.680
No. 3	UD Gothic (Company D)	0.360
No. 4	UD Reimin	-0.620
No. 5	Mincho (Company A)	-1.320

Vertical writing	Font name	Scale value
No. 1	UD Shin Maru Go゠	0.660
No. 2	Gothic (Company A)	0.320
No. 3	UD Gothic (Company D)	0.280
No. 4	UD Reimin	-0.420
No. 5	Mincho (Company A)	-0.840

Vertical writing	Font name	Scale value
No. 1	UD Shin Maru Go	0.655
No. 2	Gothic (Company A)	0.255
No. 2	UD Gothic (Company D)	0.255
No. 4	UD Reimin	-0.400
No. 5	Mincho (Company A)	-0.764

Horizontal writing	Font name	Scale value
No. 1	UD Shin Maru Go	0.880
No. 2	Gothic (Company A)	0.580
No. 3	UD Gothic (Company D)	0.420
No. 4	UD Reimin	-0.700
No. 5	Mincho (Company A)	-1.180

Horizontal writing	Font name	Scale value
No. 1	UD Shin Maru Go	0.460
No. 2	Gothic (Company A)	0.440
No. 3	UD Gothic (Company D)	0.220
No. 4	UD Reimin	-0.400
No. 5	Mincho (Company A)	-0.720

Horizontal writing	Font name	Scale value
No. 1	UD Shin Maru Go	0.575
No. 2	Gothic (Company A)	0.375
No. 3	UD Gothic (Company D)	0.150
No. 4	UD Reimin	-0.350
No. 5	Mincho (Company A)	-0.750

Vertical writing	Font name	Scale value
No. 1	UD Shin Maru Go	0.800
No. 2	UD Gothic (Company D)	0.280
No. 3	Gothic (Company A)	0.120
No. 4	UD Reimin	-0.400
No. 5	Mincho (Company A)	-0.800

Vertical writing	Font name	Scale value
No. 1	UD Shin Maru Go	0.764
No. 2	Gothic (Company A)	0.255
No. 3	UD Gothic (Company D)	0.182
No. 4	UD Reimin	-0.400
No. 5	Mincho (Company A)	-0.800

Vertical writing	Font name	Scale value
No. 1	UD Shin Maru Go	0.560
No. 2	UD Gothic (Company D)	0.320
No. 3	Gothic (Company A)	0.280
No. 4	UD Reimin	-0.360
No. 5	Mincho (Company A)	-0.800

Horizontal writing	Font name	Scale value
No. 1	UD Shin Maru Go	0.760
No. 2	Gothic (Company A)	0.280
No. 3	UD Gothic (Company D)	0.160
No. 4	UD Reimin	-0.400
No. 5	Mincho (Company A)	-0.800

Horizontal writing	Font name	Scale value
No. 1	UD Shin Maru Go	0.764
No. 2	Gothic (Company A)	0.291
No. 3	UD Gothic (Company D)	0.145
No. 4	UD Reimin	-0.436
No. 5	Mincho (Company A)	-0.764

Horizontal writing	Font name	Scale value
No. 1	UD Shin Maru Go	0.523
No. 2	UD Gothic (Company D)	0.338
No. 3	Gothic (Company A)	0.308
No. 4	UD Reimin	-0.431
No. 5	Mincho (Company A)	-0.738

C. Verification of Morisawa UD Fonts Legibility / Readability for People with Low Vision on Digital Devices

This test determines whether people with low vision get the same results with both A and B.

Verification results

Verification of device differences (A): The maximum reading speed (MRS)*3 is higher on paper than on digital devices (Fig. 5), but no significant difference was found between paper and digital devices in terms of reading acuity (RA)*4 and critical print size (CPS).*5 These results are consistent with the results for people with normal vision using Heisei Mincho font.

Verification of superiority of UD fonts on digital devices (C): Most of the participants chose UD Shin Maru Go as the easiest font to view (Fig. 6) which suggests the superiority of UD fonts in terms of ease of viewing.*6 These results matched the test results of the low vision simulation with a blur filter on people with normal vision.

Verification conditions

Devices: Paper and digital device (iPad Air)

There were three differences from the test on people with normal vision, as stated below.

Viewing distance: The most optimal viewing for each participant (The distance was fixed at 30 cm for people with normal vision)

Character size: Each participant chose the easiest size to recognize from 12, 18, 22, or 26 point. (The size was fixed at 22 point for people with normal vision in the paired comparison test.)

Test repetitions: 15 times (10 times for people with normal vision in the paired comparison test)

Evaluation method

The same method was chosen as in verifications A and C on people with normal vision.

Verification of device differences (A): Using a readability test machine and MNREAD-J*7 for both paper and digital device, three indices were measured: (1) reading acuity (RA), (2) critical print size (CPS), and (3) maximum reading speed (MRS). Heisei Mincho font was used.

Verification of superiority of UD fonts on digital devices (C): Using an iPad Air, a test was conducted using a paired comparison program and the results were analyzed. During the test, participants were asked repeatedly which of the two fonts was easier to view. The test was repeated fifteen times.

Fonts compared

Verification of superiority of UD fonts on digital devices (C): Vertical and horizontal writing: UD Shin Maru Go, UD Reimin, UD Gothic (Company D), Gothic (Company A), Mincho (Company A) (5 fonts total)

Notes

*3 The fastest speed at which a participant can read when print size is optimal. It is measured in the unit [letters/minute]. Higher values indicate better readability.

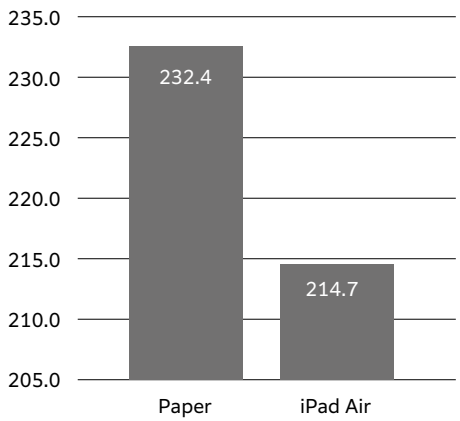
*4 The smallest print that can be read. It is measured in the unit [logMAR] (the logarithm of the character size expressed as visual angle). Lower values indicate better readability.

*5 The smallest print that supports the maximum reading speed. It is measured in unit [logMAR]. Lower values indicate better readability.

*6 If the test were to be conducted using UD Shin Go in place of UD Shin Maru Go, the difference in scale of the results would be insignificant, then there is a strong possibility that UD Shin Go would exceed other Gothic fonts. The test results showed that many participants chose UD Shin Maru Go, but in an oral survey, respondents tended to prefer square Gothic to rounded Gothic.

Fig. 5 Difference in maximum reading speed between paper and digital devices

Item measured: maximum reading speed. Font: Heisei Mincho.



[characters/minute]

*7 MNREAD-J

A method of verifying readability. Developed by Prof. Gordon E. Legge of the University of Minnesota, MNREAD also has a Japanese version created by Prof. Koichi Oda of Tokyo Woman's Christian University. MNREAD is the most used verification method internationally. MNREAD-J was designed as follows to control the degree of difficulty of sentences.

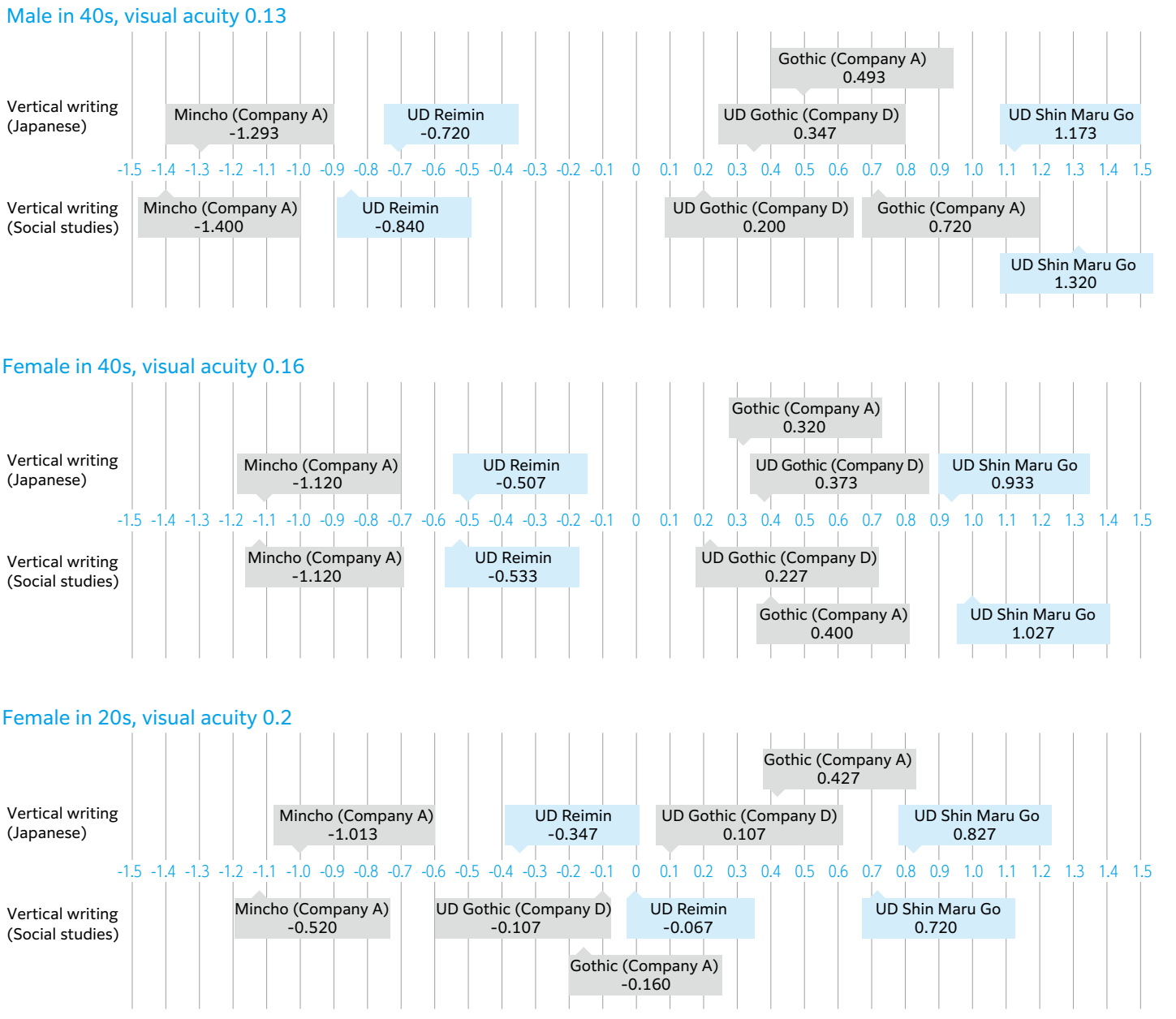
- 30 characters with no punctuation marks
- 10 characters on a line, with 30 characters laid out over three lines
- Up to eight kanji per sentence
- Words are not split between lines

The test measures reading efficiency by having the participant read these sentences out loud as quickly as possible, with no mistakes. There are three quantifiable indices were measured, as below.

(1) Reading acuity (RA) [logMAR]
(2) Critical print size (CPS) [logMAR]
(3) Maximum reading speed (MRS) [characters/minute]

MNREAD-J uses Heisei Mincho however for this test, charts were prepared with various fonts to compare.

Fig. 6 Test results by paired comparison method (excerpt)



Number of participants

A. Verification of Morisawa UD fonts legibility / readability on digital devices (1)
Overall ranking method

・No low vision simulation: 19 persons
・Low vision simulation with a blur filter: 19 persons
・Low vision simulation with cataract simulation goggles: 19 persons

B. Verification of Morisawa UD fonts legibility / readability on digital devices (2)
Paired comparison method

・Preliminary test (to find differences in results according to technique and select stimulus): Up to 25 persons
・Preliminary test (to find optimal character size): Up to 15 persons
・Main test (to verify superiority of UD fonts): 6 persons

C. Verification of Morisawa UD fonts legibility / readability for people with low vision on digital devices

・Test with MNREAD-J (to verify differences between devices): 15 persons
・Test by paired comparison method (to verify superiority of UD fonts): 15 persons

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Reference

Verification of the differences in ease of character viewing on paper and on digital devices

This verification test shows whether there was a difference in the ease of viewing fonts on digital devices and the ease of viewing characters on paper, which was the premise of this report.

Verification results

In the case of low vision simulation with a blur filter, there is a significant difference in reading acuity. Participants could read smaller characters on digital devices than on paper, and differences in reading speed were found based on the font used. When there was no low vision simulation, and when there was low vision simulation with cataract simulation goggles, there was no difference between digital devices and paper in terms of reading capability.

Verification conditions

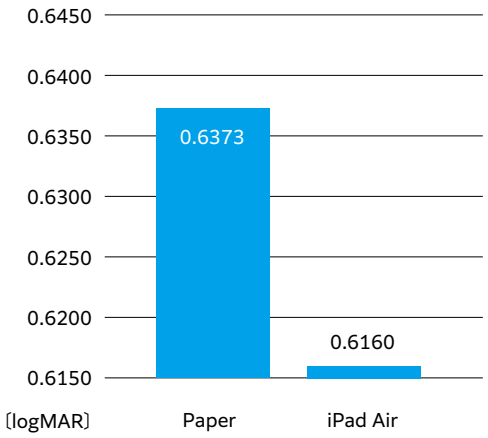
Devices: Paper and digital device (iPad Air)
Visual acuity conditions: (1) No low vision simulation / (2) Low vision simulation with a blur filter / (3) Low vision simulation with cataract simulation goggles

Evaluation method

Using a readability test machine and MNREAD-J with for paper and digital device, three items were measured: (1) reading acuity, (2) critical print size,*4 and (3) maximum reading speed.

Differences of reading acuity on paper and on digital devices

Vision acuity conditions:
Low vision simulation with a blur filter
Item measured: Reading acuity.
Font: UD Shin Go.



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