Outlining Guidelines for the Development of Universal Design Hangeul Typefaces

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Abstract

Background The design of new typefaces is going towards the direction of multilingual, multiscript and cross-platform solutions, delivering globally a consistent appearance. Having reference guidelines to facilitate the development of highly legible typefaces can be a further improvement in this context and can help to maintain a clear focus on the benefits for the end-user. The studies on this specific topic at the local level have been barely considered by the design community. This paper aims to define the key issues in current Korean typeface design and to determine guidelines for the development of Universal Design (UD) Hangeul typefaces.

Methods Two correlated qualitative tests were conducted. The first test aims to select, among widely used Hangeul typefaces the most proper one to run the following test. The second test intent is to determine specific legibility issues. The participants in these tests were selected among the local population. Half of the participants were selected among the elderly, more prone to visual acuity issues, in order to detect eventual relevant variances in the results when compared to the average population.

Results The tests demonstrated that legibility issues are correlated to the letters' deformation derived by the alphabetic syllabary nature of the Korean writing system, which implies compression and stretching of the letters to fit a square block. Another legibility issue is related to the spacing between the different letters used to build a single syllable/block. Specific legibility issues have been determined, together with their recurrences, allowing to organize these issues in a scale of priority. Stroke thickness emerged as another influencing factor affecting the legibility of the typeface. No significant difference has been observed in the elderly sample when compared to the average population. This reinforces the idea that the legibility issues are intrinsic to the typeface more than relative to visual acuity issues.

Conclusions After highlighting specific legibility issues, this paper outlines three principles that should be considered in the development of a UD Hangeul typeface. The first two principles are related to the syllabic blocks writing system: reducing the compression/stretch of the letters and maintaining letter separation into the single block. The third principle is to maximize the stroke thickness without violating the first two principles.

Keywords Universal Design, Hangeul, Typeface Design, Legibility, Design for All

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1. Introduction

1. 1. Typefaces design in the current global context

The design of new typefaces is going towards the direction of multilingual, multi-script and cross-platform solutions. Both the open-source and the proprietary proposals offer a variety of world language fonts to cover non-Latin scripts, often including CJK sets (Chinese, Japanese, Korean).

The emblematic example of this trend is Noto "beautiful and free fonts for all languages" family (Google, 2016), supporting more than 800 languages and 100 writing scripts (Monotype, 2016); also the independent Typoteque type foundry, designing more than 400 fonts in the last two decades, explicitly states that the focus is now on extended language support (Typoteque, 2019), adding to their catalogue font families with over 200 languages support like the "whole-world" Ping typeface. Historical typeface design company Monotype, also released its own "font for everywhere", named SST, supporting 93 languages (Monotype, 2017).

As these type foundries state, these font families are generated to deliver a consistent brand identity, distributing contents globally, across different platforms and media.

While Google is aiming to "support all languages with a harmonious look and feel" or Typoteque is providing a "multilingual solution for global and local audiences and world-wide brands" or Monotype is bringing "harmony and personality to communications across cultures", so focusing on the semantic value of typography as the core priority of the design, having reference guidelines to facilitate the development of highly legible typefaces can be a further improvement in this context, helping in maintaining a clear focus on the benefits for the end-user.

1. 2. Legibility issues studies and Hangeul typefaces

Factors that can influence legibility can be classified as extrinsic and intrinsic (Bigelow and Matteson, 2011). Extrinsic factors have been studied extensively, for example in the automotive field, and became the subject of quantitative evaluations, that allowed the writing of standard documents (e.g. ISO 15008 2009). These extrinsic factors, like size, illumination, contrast, polarity and color, influence legibility and readability.

As stated by Bigelow and Matteson, intrinsic factors like case, width, weight, stroke modulation, form groups, serifs and slant has not been studied as extensively.

Additionally, Hangeul combines the features of alphabetic and syllabic writing systems, it has been described as an "alphabetic syllabary" by some linguists (Taylor, Insup, 1980 and Pae, Hye K., 2011). This system differs from the Latin-based system that has been considered in the majority of the studies related to the legibility theme.

Furthermore, studies about Korean typefaces focus mostly on the historical-heritage themes (e.g.: ZS Kim, 2006), the analysis of the typography state of the art (e.g.: KS Lee, 2007) or they face the theme of legibility in very specific cases (e.g.: KS Lee, 2007 /2).

While studies that promote the development of Universal Design typefaces in non-Latin-based countries already appeared (Hiroyuki et al, 2011; Punsongserm et al, 2017), there is a lack of these studies that consider Hangeul writing system.

The aim of the study presented in this paper is to provide insights about specific legibility issues in the most common Korean typefaces and defining some principles as a base for an eventual development of a UD typeface, characterized by an improved legibility.

1. 3. Korean demographic transition and visual acuity issues

Some consideration about Korean population are also motivating this study. The number of people aged over 65 increased by 5 percent year on year to 7.11 million, accounting for 14.2 percent of the total population last year (Korean Statistics, 2018). This officially makes Korea an "aged society," as it is defined by the United Nations (United Nations/World Health Organization, 2010).

The correlation of the lowering in visual acuity and aging is a phenomenon that has been treated deeply in ophthalmology (e.g.: Ronald Klein et al, 2006).
Studies related to the theme of visual acuity and aging, correlated with the legibility issues have also been conducted (Inoue, Akitsuki, 1998; T Petterson, 1994).
Thus, an increasing part of Korean population will be experiencing for a longer time in their lives' visual acuity related issues. A higher legibility typeface can become a relevant improvement in elderly people lives.

2. Method

In order to understand specific flaws in Hangeul typefaces, two correlated tests have been conducted. Here below named also Test A and Test B.
Test A is a preliminary comparative test and has the scope of selecting the typeface to be used while conducting Test B. The secondary scope of Test A is to determine the correlation between the font different features and the preferences expressed by the participants.
Test B is a qualitative evaluation test, which has the scope to highlight specific flaws in the legibility of Hangeul typefaces.
The participants involved in these two tests have been selected among the local population. On a total of 107 participants, 45 of them belong to the elderly population (over 65 years old), to detect eventual relevant variances in the results, compared to the average population, since elderlies are more prone to visual acuity issues.

2. 1. Notes about different media

Nowadays the different perception between printed media and digital media, as recent studies reveal, is more a matter of preference or habit than a matter of measurable differences in favor of one of the two. The reading effort as eye strain tests (Kretzschmar et al., 2013), or text comprehension tests (Myrberg at al., 2015; Baron, 2017) show no measurable difference, even if the preference is still in favor of the printed media.
For the purpose of this study, as specified more in detail in the following sections, all the material presented to the participants has been printed, following what is still considered the most preferred medium. A further integration to this study could be performed using digital media to understand if there could be relevant discrepancies in the results.

2. 2. Test A – Typeface selection and legibility threshold considerations

To minimize bias in Test B, which has the scope to extract specific legibility issues, a comparative Test A has been designed to select the most legible typeface among the most common ones available to the general public (2.2.1). Within this same comparative Test A, assuming that at the decreasing in size of a typeface, the legibility also diminishes, size has been included as a variable parameter, to determine the thresholds under which the different typefaces present legibility issues.
Another clarification worth mentioning regarding the preparation of Test A: a very common assumption in typography is that serif fonts, which have ornamental strokes at the tip and the base of each letter, are easier to read on paper than sans serif fonts, which do not have serifs. This is because it is believed that serifs help distinguished each individual letter (e.g.: Albers, 1963), but more recent studies (e.g.: Arditi et al., 2005) demonstrated that serifs do not significantly increase legibility; additionally, the studies that connected legibility issues and the presence of serifs did not consider Korean typefaces, thus no assumption about this theme was plausible and both serif and sans-serif typefaces have been included in this test.
Seven typefaces have been considered as candidates: four among the most common desktop and mobile Operating System standard fonts (StatCounter, 2019), two among the most used fonts on the web in South

Korea (R. Koehler, 2010) and the typeface from the most read newspaper in South Korea (Korea Audit Bureau of Certification, 2018).

2. 2. 1. Typefaces candidates

Following Statscounter Global Stats reports as of April 2019, Windows (45%), Android (35%), iOS (14%) and OS X (4%) are the highest market sharing operating systems in South Korea, thus here are the first four typefaces candidates:

Malgun Gothic (맑은 고딕) is a Korean sans-serif typeface, developed as a replacement of Dotum (돋움) and Gulim (굴림) as the default system font for the Korean language version of Windows Vista. The adjective "malgun" (맑은) means "clear" in Korean, thus making a direct translation of the font's name would be "Clear Gothic". Its elements are created based on the typeface of Hunminjeongeum (훈민정음), and streamlined with the modern form of characters as well as upright and well-regulated strokes. The font is very legible at small sizes with its moderate open counters and its even inter-character spacing and visual center-line maximize the readability (Microsoft Corporation, 2017).

Noto is the font family developed by Google Inc. in collaboration with Monotype Imaging with the "aim to support all languages with a harmonious look and feel" (Google, 2016). It is the standard font for the mobile devices operating system Android in South Korea, replacing the Roboto font, standard for the rest of the world with few exceptions in Asia. Both the sans-serif and serif declination of this font has been selected, due to the use of both in Google and Android interfaces.

San Francisco, or more specifically SF UI is a custom typeface created by Apple Inc. for the operating systems Mac OS and iOS that offers the control and flexibility to optimally display text at a variety of sizes, in many different languages, across multiple interfaces. (Apple Inc., 2019).

Gulim and Dotum are the two other candidates, chosen among the most used typefaces to produce web-based contents (R. Koehler, 2010), and as already mentioned, has been the default system fonts for previous versions of the Windows operating system.

Ming is the last typeface candidate, used by The Chosunilbo, the most read South Korean newspaper, according to the Korea Audit Bureau of Certification.

2. 2. 2. Typefaces candidates' features analysis and comparison

Open/close shapes of the letters, inter-character spacing, forms ambiguity and varying proportions; these typefaces characters have been proven to be factors influencing the legibility for what concerns Latin alphabets (Reimer at al, 2012); the most important feature in the recognition of Latin letterforms is the terminations (Fiset et al., 2008) and additionally, strokes width is also known to impact legibility (O'Day and Tijerina, 2011); other studies analyzed the influence of blocks features in Asian writing systems, considering also character complexity and stroke thickness in relation with the blocks size (Liu et al, 2016; Cai et al., 2001; Tomioka, 2007). Considering all these studies, a visual comparison has been performed and has been summarized as in Figure 1.

- Noto Sans, Dotum, Malgun Gothic and Apple SD stroke weight is visibly heavier than the other typefaces, with Noto Sans being the heaviest of the three
- Ming present the thinnest strokes among the seven typefaces
- Gulim is the most compressed typeface, vertically
- Gulim is the only typeface to be characterized by rounded edges (to connect vertical and horizontal strokes) and also rounded strokes caps
- Gulim, Noto Sans and Malgun Gothic present in different letters an atypical vertical symmetry
- Dotum present the most tilted strokes among the sans-serif typefaces
- Malgun Gothic presents the largest spacing between the different vowels in a compound vowel, compared to the similar designed Noto Sans and Apple SD

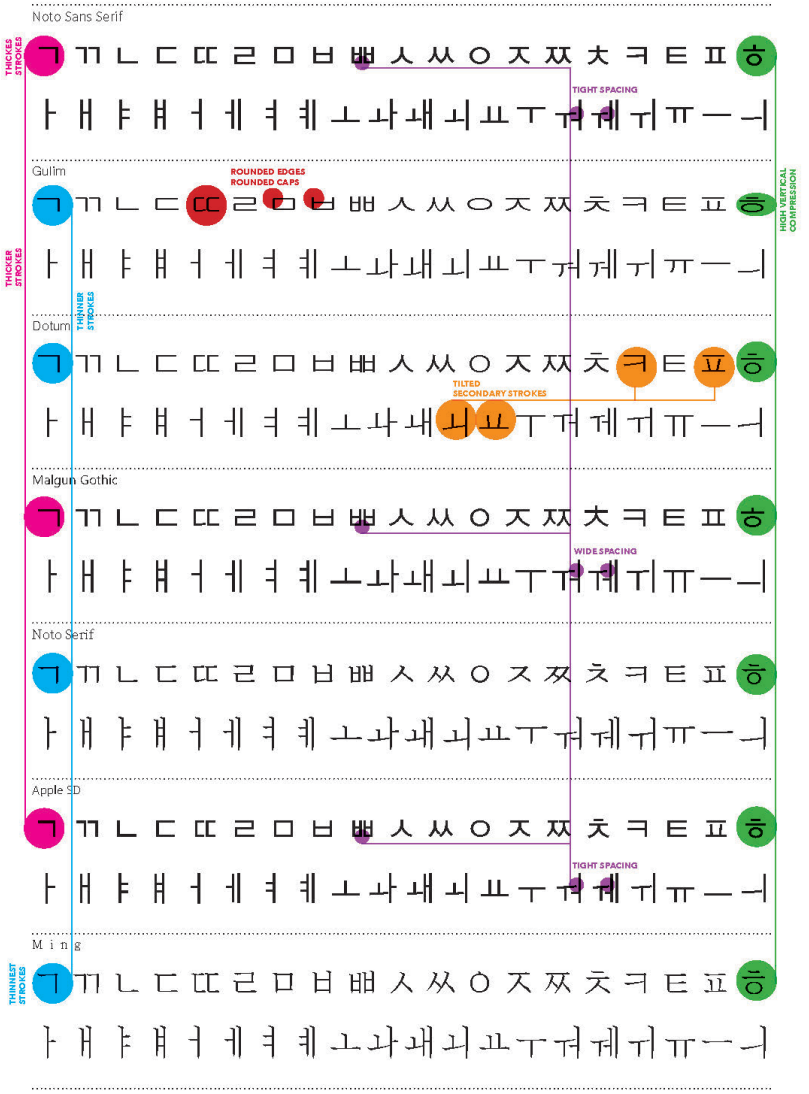


Figure 1 Typefaces candidates' visual comparison.

2. 2. 3. Non-sense paragraphs.

To reduce the bias in this comparative test, receiving a feedback focused on the legibility and minimizing the influence by the semantic content itself, a non-sense paragraph has been produced using 한글입숨 (hangul.thefron.me), a free online Hangeul paragraph generator that does not produce any sentence meaning nor maintain any sentence structure, while the paragraph consists of correct words (the "alphabetic syllabary" writing system is respected, avoiding glyphs combinations that do not exist).
The placeholder text "Lorem ipsum dolor sit amet, ..." has been used for several centuries, since 1500 AD, by typographers to show the most distinctive features of their fonts. It is used because the letters involved and the letter spacing in those combinations reveal, at their best, the weight, design, and other important features of the typeface (Microsoft, 2018).

2. 2. 4. Test A – Composition and procedure

The test consisted of 7 pages plus one containing the instructions. On each page, the nonsense paragraph has been replicated seven times, applying each time a different candidate typeface; all the typefaces weight has been set to the "regular" one, to have the most homogeneous possible comparison. This is also the only

shared weight option among the different typeface candidates. From page to page the size of the typefaces has been lowered by one point, from 9 points down to 3 points.
This test has been printed on standard A4 uncoated 80g/m2 white paper with a laser printer at 300dpi.
The target of these tests, a total of 107 people, has been selected within the local population: 45 above age 65 and 62 people from the average population. The sample of elderly people has been included to observe eventual relevant variances on the responses to the tests.
It has been requested to the participants to “place this paper sheet at the typical reading distance and trying to focus on the legibility of the text, mark the easiest to read paragraph”. Then to “try to express one preference per each page. If no clear preference is selectable, please go to the next page.”

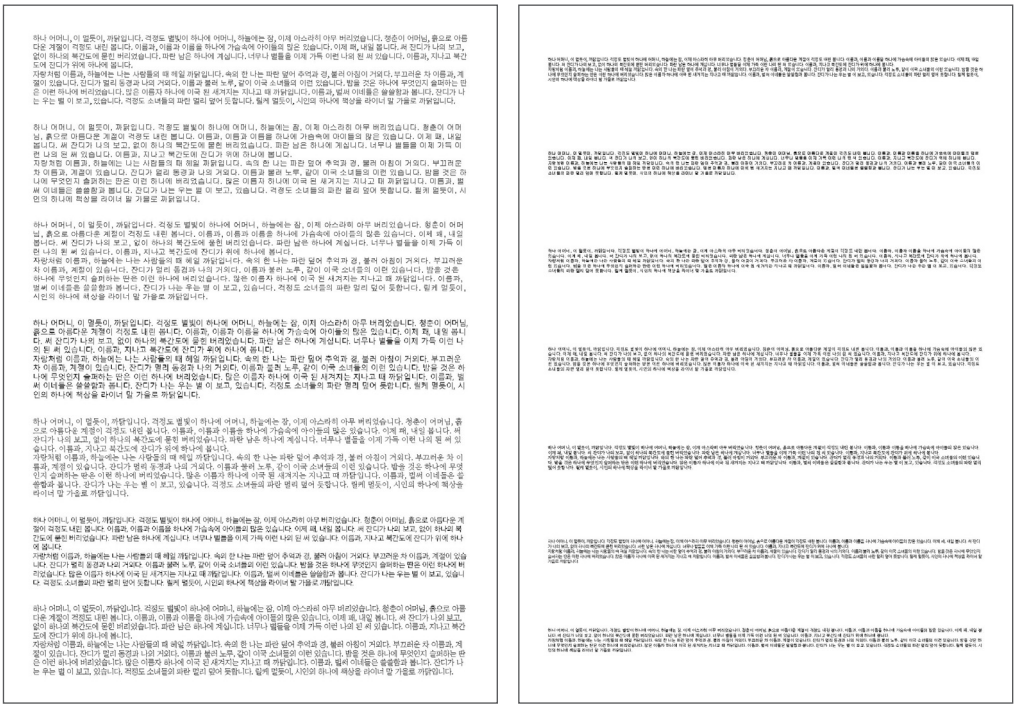


Figure 2 Pages 1 and 5 of comparative Test A.

2. 3. Test B – Hangeul typeface legibility issues test

The second test is a qualitative evaluation of the Korean typeface selected as a result of Test A. Test B has been composed with the aim of verifying two hypotheses: the first is that the alphabetic-syllabic nature of Hangeul, that imply letters deformation (compression and stretching) can influence the legibility of the letters themselves; the second hypothesis is that the separation of the letters within each syllabic block can be another legibility influencing factor. These hypotheses have been formulated deducing that a similitude can exist in between the legibility influencing factors of Latin alphabet typefaces (e.g.: Paterson D.G at al, 1932) and the legibility influencers of Korean alphabet typefaces.
These two hypotheses have been formulated also interpreting the seminal typography work of professor Ahn Sang-Soo, considered the founder of contemporary typography in Korea (Fouser R. J., 2016). While focused on the experimentation and the communicative aspects of typography as explained in his own words: “my concept is just one, to play with typography, the typographical expression”, during the Atape interview in 2007, his eponym font development implicitly includes two characters; first, his design violates the unwritten rule of creating square blocks of letters and second, he avoids totally the compression of the interspace among the letters, maintaining a fixed air among them.

2. 3. 1. Hangeul syllabic blocks short–selection

Korean letters are written in syllabic blocks with each alphabetic letter placed vertically and horizontally into a square dimension. For example, the Korean word for "honeybee" (kkulbeol) is written 꿀벌, not ㄲㅜㄹㅂㅓㄹ (National Institute of Korean Language, 2008). Letters are grouped into syllabic or morphemic blocks of at least two and often three: a consonant or a doubled consonant called the “initial”, a vowel or diphthong called the “medial”, and, optionally, a consonant or consonants cluster at the end of the syllable, called the “final”. When a syllable has no actual initial consonant, the null initial ㅇ (ieung) is used as a placeholder. Thus, for the purpose of this test, blocks containing a minimum of two letters have been selected. Not including obsolete letters, 11,172 blocks are possible to be composed in the Korean alphabet (SS Kang, 1993).

Another consideration about this test is that the scope is not to pinpoint single block issues, but to understand the overall flaws in the legibility of a Hangeul typeface, so a smaller subset that covers a consistent part of Korean grammar was considered more proper to fulfill this qualitative test needs.

About only 2,350 syllables cover more than 99.9% of the modern Korean words (SS Kang et al., 1994). It is also relevant for this scope to note that that even smaller syllables subsets cover entire parts of Korean language; as examples: grammatical morphemes are combinations of only 151 syllables, verbs in a Korean dictionary are combinations of 996 (SS Kang, 1993).

Following this consideration, on this set Test B has been built.

2. 3. 2. Test B – Composition and procedure

The selected set of syllables (996 syllables) like presented in the attachment to Prof Kang Ph.D. dissertation, are in alphabetical order. To avoid predictability of the contents derived from the logical order and a facilitated readability, the whole set has been randomized using a free online service (browserling.com/tools/random-letters), thus letting the participants to focus on the legibility of the syllables.

To find the threshold of legibility of the entire set, the same set has been printed on 8 different pages (A4 format, uncoated white 80g/m2 paper, 300dpi laser printer), lowering the size of the typeface of one point per each page, starting from a standard 10 points, down to 3 points.

To the participants has been requested to place the first page to a comfortable reading distance, then to flip through the following pages and to stop on the page where most of the syllables appear not legible. This is the non-legibility threshold. Thus, the test is performed on the preceding page. The participants have been requested to mark the syllables that presented to them issues in legibility using a highlighter.

The participants to this second test were 42 among Test A participants.

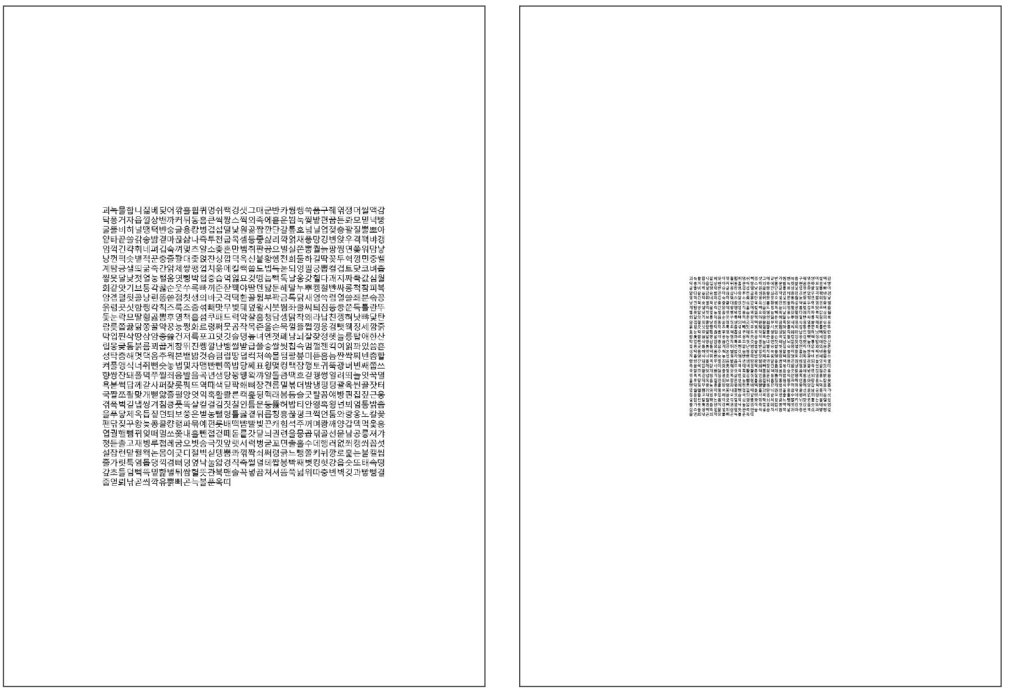
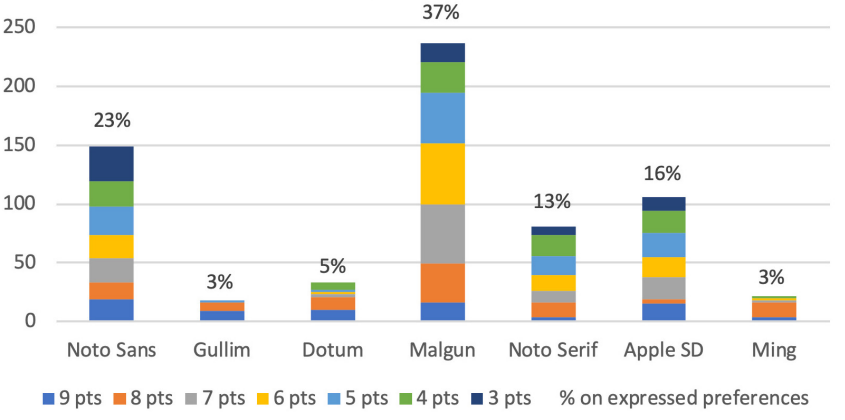


Figure 3 Pages 2 and 5 of Test B (Real size is on two A4 sheets)

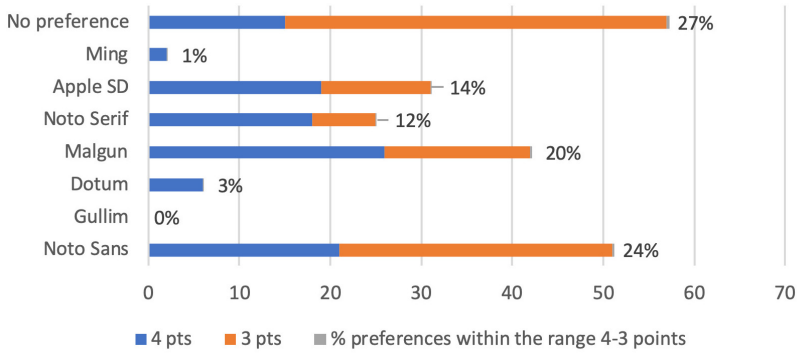
3. Results

3. 1. Test A – typeface selection results

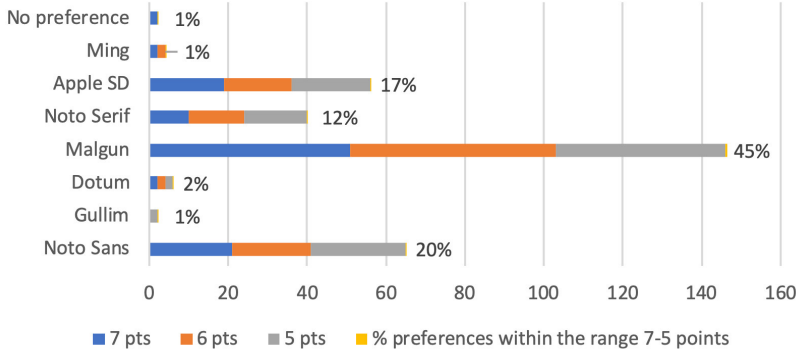
The answers from the participants have been collected in table A, then the data have been elaborated and visualized in charts A, B, C, D and E following the observations expressed in the method chapter, hence the charts below consider: the total of preferences expressed overall (average population and elderly population), the preferences for the different character sizes (9-8 points, 7-5 points and 4-3 points), a comparison between the average population and the elderly.



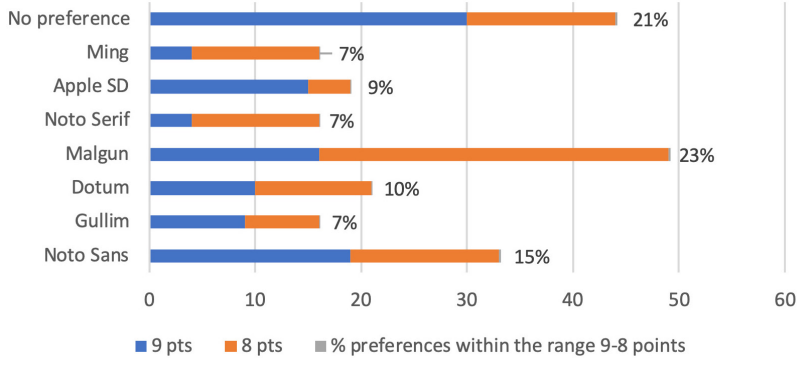
〈Chart A〉 Test A – Total of expressed preferences.



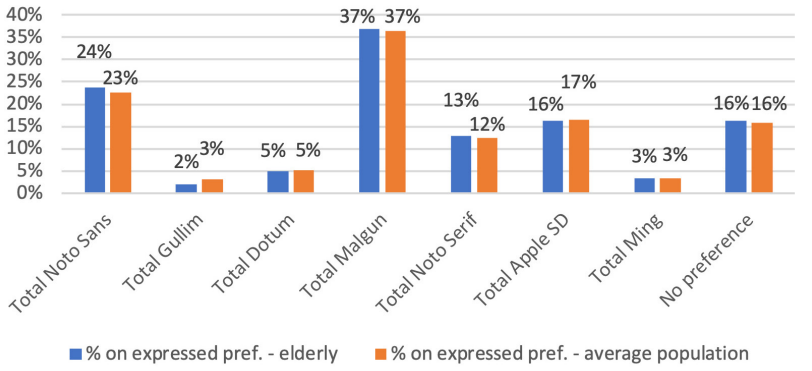
〈Chart B〉 Test A – Preferences on sizes 4 and 3 points.



〈Chart C〉 Test A – Preferences on sizes 7–5 points.



〈Chart D〉 Test A – Preferences on sizes 9 and 8 points.



〈Chart E〉 Elderly vs. Average population, preferences comparison.

From the charts above it is possible to extract the following observations:

- Malgun Gothic is the most preferred typeface overall with 37% of the total expressed preferences
- Gullim, Ming and Dotum obtained the least preferences: 3%, 3% and 5% respectively, of the total of expressed preferences
- Malgun Gothic is followed by Noto Sans and Apple SD in this order, as the most legible typefaces, reaching 23% and 16% on the total of expressed preferences. Interesting to note that these typefaces are also the ones designed with the relative higher stroke thickness.
- Noto Sans is the most preferred typeface relative to the lowest sizes (3-4 points), registering the 24% of the expressed preferences on the range. Relevant to note that Noto sans presents the thickest strokes among all the candidate typefaces.
- No relevant divergence has been observed from the answers between the elderly population vs. the average population: Noto Sans 24% vs. 23%, Gullim 2% vs. 3%, Dotum 5% vs. 5%, Malgun 37% vs. 37%, Noto Serif 13% vs. 12%, Apple SD 16% vs. 17%, Ming 3% vs 3%; thus, we can deduce with a certain reliability that typefaces legibility more than an age-related issue is intrinsic of the typeface anatomy/ features.

When the typefaces are presented in the biggest sizes (9-8 points), a significant record of non-expressed preferences is registered (21% on the sub-total of preferences on 9 and 8 points typefaces), furthermore another relevant record of non-expressed preference is present at the lowest sizes 27% of the sub-total of preferences on 4 and 3 points typefaces); we can deduce that in the first case the absence of preference is due to an easy overall legibility, in the case of the lowest sizes, we can deduce that the preference is difficult to be expressed due to the very low legibility. A part of the participants expressed these difficulties in some verbal and written notes during the test (“all same” “all easy to read”; “hard to read”, “all too tiny”).

Following the results of this test, the typeface selected to proceed with Test B is Malgun Gothic, being selected as a clear preference among the most common Hangeul typefaces, reaching the 37% of the expressed preferences, with 14 points over the second most preferred, Noto Sans.

3. 2. Test B – Typeface specific issues results

The test results have been collected and the number of times each syllable has been marked has been recorded, then the results have been divided into three ranges, marked with three different colors, like in Figure B:

- with cyan color, legibility issues reported 15 to 21 times, here below named as “Main Issues”
- with magenta color, legibility issues reported 8 to 14 times, here below named as “Major Issues”
- with yellow color, legibility issues reported 2 to 7 times, here below named as “Secondary Issues”.

Then the following observations have been noted, comparing the results with a typeface anatomy / features description, similarly to what has been done in chapter 2.2.2 for the Typefaces candidates’ considerations.

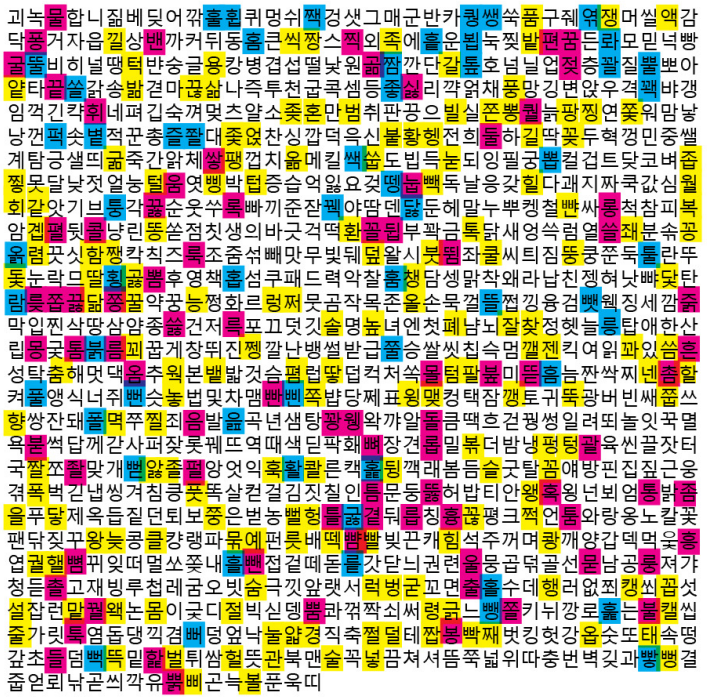


Figure 4 Test B recorded data.

“Main Issues”:

- blocks of three or four letters composed by a medial horizontal vowel (ㅗ, ㅜ, ㅡ, ...) suffer all of high legibility issues when the initial is a double consonant or a ㄹ or a ㅎ or a ㅍ. This can be related with the compression of the vertical secondary stroke. E.g.: 뽑, 릍, 훑, 폴
- blocks of three letters starting with a double consonant and of which the vowel is a compound vowel build with four or five strokes (ㅘ, ㅝ, ㅞ, ㅙ, ㅞ, ㅙ). This can be related to the general compression of the top half of the block, that can reach 7 to 9 strokes. E.g.: 꽐, 꽥, 퀑
- blocks of two and three letters of which the initial is a ㅃ followed by a vertical vowel or diphthong. This can be related to the horizontal compression of the initial and the medial, leading to a sequence of 5 to 6 vertical strokes in a row, making the secondary horizontal strokes difficult to be recognized. E.g.: 빽, 뻐, 뼁, 삔
- blocks of three letters of which the initial is a double consonant and the medial is a dark vowel (ㅓ, ㅔ, ㅕ, ㅖ, ...) suffer more of low legibility compared to the blocks with the same features but composed with bright vowels (ㅏ, ㅑ); this can be interpreted as a consequence the fact that ㅏ and ㅑ secondary strokes point towards the outside of the block, thus remaining more recognizable, while ㅓ, ㅔ, ㅕ, secondary strokes pointing inwards are more keen to be cluttered, visually merging with the preceding double consonant. E.g.: 뗑, 뻔, 빽
- blocks of three letters of which the initial is a ㅎ, ㅍ, ㅌ or a double consonant and the medial is an horizontal vowel. This leads to a compression of the vowel secondary stroke and an excessive proximity to the initial above. This horizontal vowel compression appears as one of the major issues, emerging even more clearly in the second range of preferences. The same legibility issue is of course present when the final letter is a double consonant. E.g.: 훑, 흘, 흠, 홉, 뚤, 쏠, 폴

“Major Issues”:

- blocks of three letters constructed with a horizontal medial vowel (ㅗ, ㅜ, ㅡ, ...). This appears to be the most diffused legibility issue within the range. The compression of the vowel secondary stroke and furthermore the proximity or merging with the consonant above or below lower the legibility of the median vowel. The same legibility issue is persistent when the final is a double consonant. E.g.: 움, 룽, 붚, 틈, 붉, 굻, 뚫...
- blocks of three letters, that contain an open bottom design consonant like ㄱ, ㄲ, ㅅ, ㅈ as initial plus a horizontal vowel (ㅗ, ㅡ, ㅜ, ...) do not suffer of the same low legibility like mentioned at the previous point. This is an indication that the space left below these consonants, helps in distinguishing the orientation of the vowel secondary stroke(s) leading to a relatively higher legibility. E.g.: 숙, 꿆, 꼭
- blocks of three letters composed by a double consonant (ㅍ, ㄲ, ㅆ, ...) as initial and followed by a diphthong or a vowel composed by four of five strokes (ㅘ, ㅝ, ㅞ, ㅙ, ...). The top half of the syllable can contain even more than 10 strokes, implying compression and excessive proximity of the terminal part of the strokes with the adjacent ones. E.g.: 쫠, 꽝
- blocks of three letters with a double consonant as final; this is another case of compression of the top part of the block. Evidently, that the same block structure with an initial double consonant is suffering from the same legibility issue. E.g.: 붉, 줅, 꿇

“Secondary Issues”:

- blocks of three letters composed by an initial double consonant and a median vertical vowel (ㅒ, ㅖ, ㅖ, ...), are one of the most reported legibility issues in this range, independently from the specific consonants associated. Here the top part is more populated than other blocks of vertical or diagonal strokes, minimizing the spacing between the letters. E.g.: 낄, 짹, 쌤, 짬, ...
- blocks of two letters are very rarely highlighted, demonstrating that the scientific nature of Hangeul allows to maintain the legibility very high even if we do not consider the letters as single units
- blocks of two letters are so rarely marked as legibility issues, that is not possible to formulate any precise statement about possible relationships with the anatomy of the blocks), if not being designed mainly by vertical strokes. Only 태, 뻬, 폐.
- blocks of three letters constructed with a horizontal medial vowel (ㅗ, ㅜ, ㅡ, ...). Also in this range, this represents the most common issue, with 62 on the total of 186 legibility issues recorded. Confirming that compression and proximity with the initial and final letters influence legibility. E.g.: 품, 좁, 꽁...
- with reference to the previous point: blocks of three letters in which the initial is a ㄱ or ㅋ suffer less of low legibility. This is possible due to the space left by these two letters on the bottom part, avoiding excessive proximity to the medial vowel. E.g.: 군, 콕...

4. Conclusion

The results of the Test B are specific issues, that have been grouped according to the in frequency they have been reported, allowing a classification in “Main”, “Major”, “Secondary”. Furthermore, comparing the common characters of these issues, from the typeface anatomy point of view, these legibility issues confirm the two hypotheses formulated as a starting point of the test itself: letters deformation (compression and stretching) and reduction of the interspace between the letters in a single block, intrinsic in the alphabetic syllabic nature of Hangeul, influence the legibility of the letters themselves.
To solve these legibility issues three design principles can be formulated:

A. limit the compression of the secondary strokes
B. maintain the separation of the letters inside a syllable/block
C. maximize the stroke thickness, respecting the two previous principles.

As emerged in Test A, the typeface strokes' thickness also influences the legibility of the syllables, where the favorite overall and the favorite in the smallest sizes typefaces presented the thickest strokes. A further study could eventually be conducted to determine in absolute values the proper thickness per different sizes, and not in relative values like the results reported in Test A.

4. 1. Possible further deepening and correlated studies

Legibility, visibility and readability are terms that assume different meanings depending on the context and even in the typography-related literature are far from being consistently used. "Legibility is a function of typeface design, [..] readability is a gauge of how easily words, phrases and blocks of copy can be read." (Haley, 2017) and "legibility is a concern with the form and essential characteristics of each letter [...]. Visibility is determined by factors that either permit or hinder visibility entirely [...]. Readability refers to the ability for reading word-sentence-paragraph-text and running text correctly and accurately" (Punsongserm et al., 2017) summarize well the distinction adopted also in this study.

Following this distinction, the study here presented tries to address issues related to the legibility of Hangeul typefaces, thus focusing on the character design itself, not on the external factors influencing visibility nor on the text comprehension as a whole.

Consequent studies that include visibility or readability-related issues in the evaluation of the typefaces can highlight further features to be considered in the design development of a UD Hangeul typeface, i.e., distance among the different blocks, distance from different words.

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