Chapter 5

Designing legible fonts for distance reading

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This chapter reviews existing knowledge on distance legibility of fonts, and finds that for optimal distance reading, letters and numbers benefit from relative wide shapes, open inner counters and a large x-height; fonts should further be widely spaced, and the weight should not be too heavy or too light (Figure 1). Research also indicates that serifs on the vertical extremes improve legibility under such reading conditions.

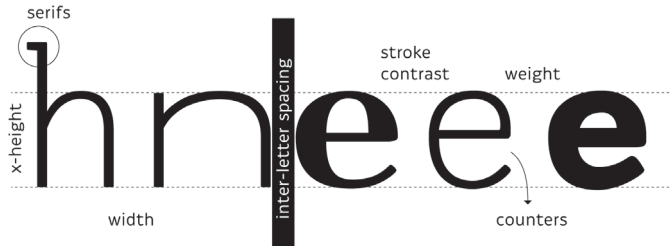

Figure 1: Matters to consider when choosing and designing type for distance reading: the placement of serifs; the size of the x-height; the horizontal width of letters; the spacing between letters; the stroke contrast; the letter counters and the weight of the typeface.

1.1 Introduction

The further away we can read the text on a sign, the longer we have to make the right navigational decision or the sooner we know if we are moving in the right direction. This question of performance is particularly important in road signage, where the added time in extreme cases, may help to prevent accidents. In airports or in dense urban areas, legible signs contribute to smoother traffic patterns and less frustrated users. Optimizing the distance legibility of signage fonts can therefore have a significant impact on people's everyday lives.

Drawing on both scientific findings, and on designer's experiences, this chapter will present the different factors that influence the legibility of fonts when read from a distance.

1.2 Disappearing details

A significant effect of distance is the loss of information in the smaller features and details. This can have a range of effects on reading performance. It appears that the information loss can partly be worked around if we understand how to compensate for this loss. When Jock Kinneir and Margaret Calvert created the British traffic sign system from 1957 to 1963, their font development resulted in a public debate on letterform legibility. Their chief critic was rival type designer, stone carver and lettering artist David Kindersley [for a detailed description see Lund, 2003]. Like others, Kindersley had observed that: 'In very small type, or in larger letters to be read at a great distance – in fact, wherever there is a question of distance in relation to size – there is always a loss of definition' [Kindersley 1960, p. 465]. To compensate for this loss in the corners of letters, Kindersley argued for the importance of the serif as it 'reinforces the individual character of the letter exactly where this loss is greatest' [p. 465]. This notion has partly been confirmed by researchers Beier and Dyson [2014] who found no difference in the overall distance legibility between sans serif and serif fonts, yet when looking at the group of letters with serifs at the vertical extremes (Figure 2), the data showed higher distance legibility. Kindersley's proposal emphasized these corners.

Figure 2: Beier and Dyson [2014] found that serifs on the vertical extremes improve distance legibility

Figure 3: The intention with the round corners of the typeface FF Info was to create an even appearance of the letter stroke on backlit signs (by Erik Spiekermann and Ole Schäfer)

In contrast other designers have chosen to create stroke endings that accept and integrate the loss of detail that can be expected. This has led to round sans serif corners. When type designer Gerard Unger [2014] was working on the font for the Amsterdam Metro early in his career (1974) , many of the signs were illuminated from within. Unger observed that when light shines through a hole of any shape or form, the light tends to soften the form and this softening appears circular. He decided to integrate this observation in the final design of the font, and consequently created round corners on the letters. A similar solution was applied in the more recent typeface family FF Info by Erik Spiekermann and Ole Schäfer (Figure 3).

1.3 Open inner counters

It may seem logical to assume that the larger the letter size, the greater the distance at which a text can be read. We might therefore think that because signs often have to fit within a limited horizontal surface area that narrow letters will be more legible because they will be able to fit in the surface area, while having a larger point size (Figure 4).

This objective, that a font for signage should be economic in the use of horizontal space, was part of the brief given to Gerard Unger, when he designed the font for the Dutch small signposts (ANWB-U) in 1996. During the development process the font was exposed to empirical distance testing [Walraven *et al.,* 1996]. The study compared the new font with two versions of the font it was replacing; one of these was both narrower and lighter in weight (ANWB-C) than the Unger font, and one was slightly wider than the Unger font with similar weight (ANWB-E).

Both fonts were altered variations of fonts found in the American road signage typeface family FHWA Series (often referred to as Highway Gothic) (Figure 5). The experiment found the performance of the new font ex-

Figure 4: The two fonts at the top are set in the same point size, yet take up very different horizontal space. The two fonts at the bottom, take up the same amount of horizontal space, yet the condensed version is in 47 point size while the expanded version is in 25 point size.

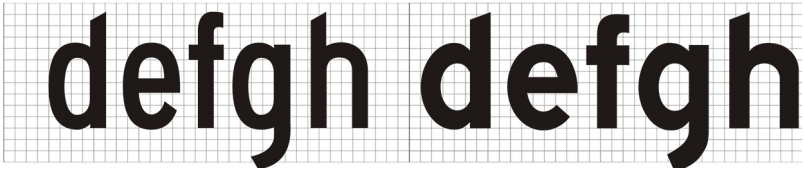

Figure 5: The Highway Gothic Series was originally developed for the American road system. This example shows ANWB-C or Series C with narrow letter shapes (left) and ANWB-E or Series E, which has wider letter shapes (right) (MUTCD 2000).

ceeded that of the narrow version by 13%. It was, however, slightly inferior to the wider version by 3%. Unger[a] has said that the results confirmed to him that large inner letter counters improve distance legibility, a feature he emphasized as much as possible within the limited horizontal width that he had to work with (Figure 6).

Quite a few other designers of traffic typefaces have spoken in favor of large counters. On several occasions, Jock Kinneir [1978, p. 344; 1980, p. 66] noted the significance of having clear and open counters, to avoid clogged counters and therefore more ambiguous letter shapes when the letters and numbers are viewed through the glare of headlights. He also

a Personal communication (December 2012)

Figure 6: In the font ANWB-U, Gerard Unger aimed at creating large inner counters, while working on saving horizontal space as well

emphasized that even while narrow glyphs can be set larger and taller, this will not improve on the legibility if the two opposite sides of the counters are too close and begin to seem to merge [Kinneir 1980, p. 66]. More recently, type designer James Montalbano collaborated with Meeker & Associates on the design of the typeface ClearviewHwy that is intended to eventually replace Highway Gothic on American roads. In an interview with the New York Times, Montalbano voiced his opinion of the letter counters of Highway Gothic, finding them too small. He too refers to the problem of headlights' illumination causing problems with recognizing letters and numbers. In the case of the letters 'o' and 'e' Montalbano describes them as appearing like 'bullets that you couldn't put a pin through' [Yaffa 2007, p. 4] meaning that the counters seem to disappear. A similar observation has been made by type designer Adrian Frutiger in relation to his traffic sign typeface Frutiger Astra, where he enlarged the counters as a way of ensuring that letters like 'e' and 'a' can be easily distinguished and do not appear like dots from a distance [Linotype, 2009].

These designers all realized the significance of opening up the counters for distance legibility and found that it is essential to produce fonts where the inner white area is as big as possible.

Large counters can be created in several ways. One way is related to the x-height, and another way is related to the width of the glyph.

1.3.1 *The x-height*

In many of the lowercase letters, the majority of the details are found within the x-height. Hence it is the x-height and not the point size that defines the perceptual size of the font, a fact that has been overlooked in the history of legibility research too often (Figure 7). Therefore the larger the x-height the larger the font is perceived to be.

An early legibility study by Elisabeth Roethlein [1912] confirms this. Roethlein tested the distance legibility of the individual letter in a series of different fonts, and as shown in Figure 8, the fonts of the larger x-height were also the fonts that were legible from the greatest distance.

There is, however, a limit to how big the x-height can be. In his publication 'Letters of Credit' from 1986, typography writer Walter Tracy ar-

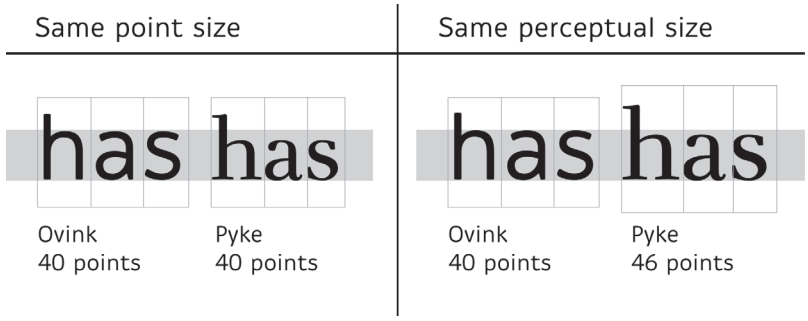

Figure 7: The font Ovink has a larger x-height than the font Pyke; when set in the same point size Ovink will appear larger than Pyke while working on saving horizontal space as well

New Gothic	236.4
Bulfinch	233.6
Clearface	229.5
Century O.S.	228.0
Century Exp.	226.7
Cheltenham W	224.3
Jenson	214.7
Della Robbia	214.7
Cushing O.S.	206.4
Cheltenham O.S.	206.4
De Vinne	204.8

Figure 8: A selection of the fonts tested by Elisabeth Roethlein [1912] with their distance thresholds (right column). This table demonstrates that large x-heights tend to be read at greater distances than small x-heights.

gued that, although short descenders on letters such as g, j, p, q and y may be 'displeasing to the eye' [p. 50], this is not as problematic as too short ascenders on letters such as b, d, h, k and l, which can result in the letters losing their individuality. A classic example of this problem is the confusability between h and n (Figure 9).

There is consequently a limit to how big the x-height can be before it starts to interfere with the parts that differentiate one letter from the other.

Figure 9: If the x-height is too big, it can result in misreading of certain letters

1.3.2 *Letter width*

In order to inform the choice of typeface for signs at London's Heathrow Airport, Robert Waller [2007] compared the fonts BA Signs, Frutiger Bold, Frutiger Roman, Vialog, and Garamond Italic. He gradually enlarged the test material until the participant was able to identify the word. The data showed that the narrow Vialog was less legible than the two Frutiger weights and the BA Sign fonts, all of which were wider in horizontal proportions than Vialog (Figure 10).

In another investigation, researchers [Beier and Larson, 2010] measured the number of errors made by participants while identifying letters at a short exposure and at a distance, and found that at distance reading, narrow designed characters tended to produce more errors than wider designed characters (Figure 11); this was most evident in fonts of low stroke contrast.

Over the years, several studies have looked into the legibility of the Highway Gothic family. In 1939, Forbes and Holmes compared the legibility distances of the narrow series B with the wider series D (Figure 12), and found that both at day and night time conditions, the wider versions delivered the best performance. Another researcher, Thomas Schnell

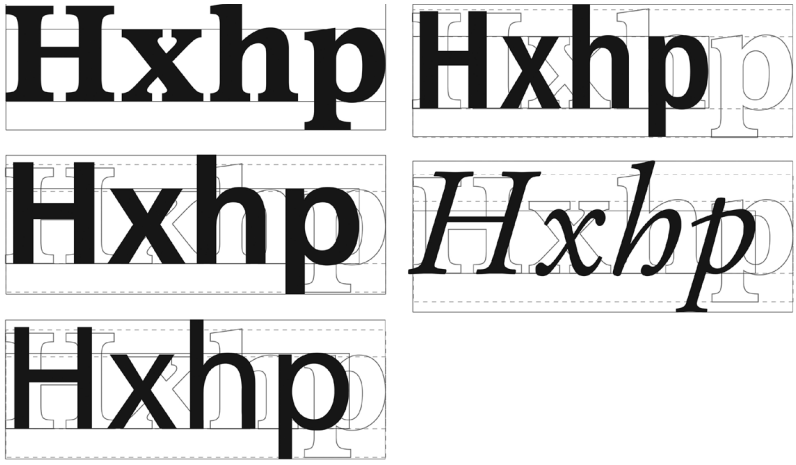

Figure 10: The fonts BA Signs, Frutiger Bold, Frutiger Roman (left), Vialog, and Garamond Italic (right), tested by Robert Waller [2007]

[1998] also looked into different aspects of the distance legibility of the Highway Gothic family. As part of his PhD studies, Schnell investigated the contrast threshold on a computer screen, starting out with the same luminance between stimulus and background, and then gradually adding visual contrast until participants could identify the test material built out of uppercase letters and numerals. Under these conditions, Schnell found that the wider fonts resulted in better performances than the narrow.

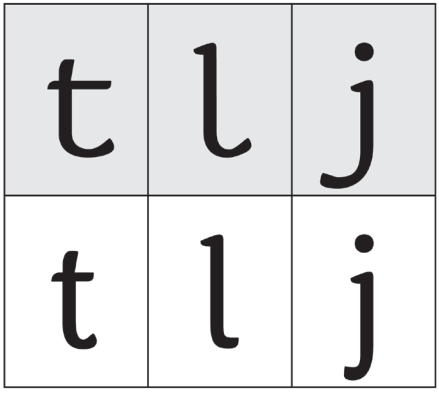

Figure 11: At distance reading and at short exposure, wider letters (top) produced a higher identification rate than did narrow letters [Beier and Larson, 2010].

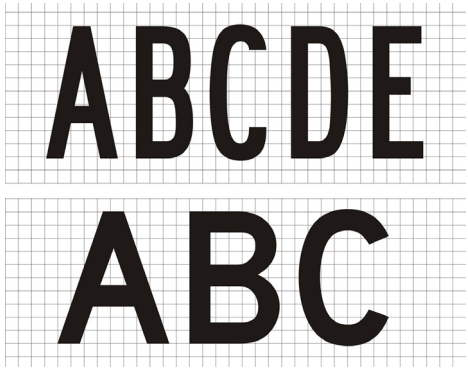

Figure 12: Highway Gothic series B (top) and series D (bottom)

Applying two methods, one based on luminance, and one based on distance threshold, Curt Berger [1948] studied different variations of the digits 5 and 0, all of same height, stroke weight, and contrast, but varying in horizontal size. The findings demonstrated that the wider the digits the more legible they became. Elisabeth Roethlein [1912] further reported a distance legibility investigation of a number of fonts within the family Cheltenham Oldstyle, which found the Wide and the Bold versions to be legible at a greater distance than the Bold Condensed, the Ordinary, and the Italic versions (Figure 13).

A font of wider proportions would need to be scaled down in size to fit a limited surface area; which then will result in a smaller point size (Figure 4). The challenge is to identify the optimal height-width ratio that enables open inner counters without having to scale down the letter size too much.

1.4 Letter weight

Defining the optimal letter weight is a difficult matter. If the stroke is too light, the characters might become invisible when viewed from a distance. The opposite is also a problem. If the stroke is too heavy, the counters will become too small and result in illegible letter shapes.

When white text is placed on a dark background; when light is projected through the glyphs; or when a sign is made out of reflective material, the phenomenon known as halation or irradiation can cause problems for readers (Figure 14). The blurring of light around the bright area of the

Bold	**Bold Condensed**
Wide	Ordinary
	Italic

Figure 13: The different styles of the Cheltenham Old Style font family tested by Roethlein [1912]. The fonts in the left column of fonts were read at a greater distance than those in the right column.

Figure 14: A simulation of halation

sign results in a 'halo', which makes it visually bleed into the surrounding areas. The effect of halation appears to vary depending on the nature of the 'halo'. In an extended review of relevant legibility research Helmut T. Zwahlen and his colleagues [1995] found that white text on dark background, generally requires a lighter stroke weight than dark text on white background. In some situations this will be solely an aesthetic adjustment, while in others the 'halo' surrounding the glyphs will cause significant reductions of legibility. This phenomenon is further evident in the data of the test studies carried out in connection with the ClearviewHwy typeface family [Garvey *et. al*, 1997; Holick *et. al,* 2006]. These studies found that in nighttime conditions the Clearview font could be read from farther away than the slightly heavier Highway Gothic series E. The same difference was not seen in daytime conditions, where the two were read equally well.

1.5 Inter-letter spacing

'Inter-letter spacing' (also called fitting or metrics) is the amount of space between all characters in a font, this being in contrast to 'kerning', which is the adjusted amount of space between two specific characters. In a

design guide for the implementation of the Highway Gothic Series, the Federal Highway Administration stated that: '…tests have shown that, for any given legend, better legibility can be obtained by using a relatively wide spacing between letters than by using wider and taller letters with a cramped space' [MUTCD, 2000, p. 8-1]. The statement suggests that inter letter spacing is one of the most central parameters when creating type for distance reading, however, the Highway Administration does not provide any references to their sources. In an investigation into distance legibility of night-time guide signs, Holick and Carlson [2003] set out to study the effect of four different spacing settings: one in Highway Gothic Series E, and three in the sans serif typeface family ClearviewHwy 5W. One of the ClearviewHwy fonts had a 3% reduction of the default spacing value, and another had a 6% reduction of the default spacing value. All fonts were tested with white text on green background. The experiment found no statistically significant difference between the three spacing values of the ClearviewHwy font, suggesting that for a significant difference to be found, the difference between spacing values may need to be greater than 6%.

Several renowned type designers have emphasized the importance of large inter-letter spacing in fonts designed for distance reading. One of these, designer Erik Spiekermann, has pointed out that too narrow letter spacing is a common flaw in signage systems [Spiekermann, 2006]. He further puts the argument forward that when reading a sign we do not read it in the same way as we do in continuous text, but instead decipher each letter of the text. As signs often contain single words with no additional context, Spiekermann finds that all characters under these circumstances need to be more clearly separated from each other.

Jock Kinneir [1978] made a similar observation. He referred to the phenomenon shown by pointillist painters that forms tend to merge when viewed from afar. These designers have observed a phenomenon identified by researchers as the 'crowding effect' or 'contour interaction', where neighboring letters within a word interfere with each other. This interference makes it harder to identify the individual letters. The phenomenon is most evident under perceptual conditions of low resolution, which occur when reading at a distance [Hess *et al.,* 2000; Liu *et al.,* 2001].

A couple of field experiments in the 1950s looked into the inter-letter spacing of the Highway Gothic Series. One of these, carried out by Harry

W. Case and his colleagues [1952] was concerned with the distance legibility of individual uppercase letters of the Highway Gothic Series E font (Figure 5). The study showed a difference in legibility depending on the type being set in positive or negative contrast, and found that black type on a white background was slightly more legible under a narrower spacing setting, and that white type on a black background was most legible under a wider spacing setting (Figure 15).

In another experiment from the same period, David Soloman [1956] looked into the influence different spacing values have on words set in the three Highway Gothic Series fonts E, C, and ED (the latter being similar in width but slightly thinner than series E) (Figure 5). The study was carried out in a dark parking lot using dipped headlights, with test material made out of white reflectorized material mounted on a black non-reflectorized panel. The findings confirmed the earlier results of Case and his colleagues by showing that distance legibility of white type on a black background increases as the spacing value increases. It appears that to reach a high level of legibility, the irradiation that affects the type under these conditions calls for a larger amount of space between the glyphs, and this effect is not as strong when dark text is set on light background.

Figure 15: Due to the bleeding of white into the dark background, Harry W. Case and his colleagues [1952] found that light text on black is more legible with a larger amount of inter-letter spacing (here illustrated with the typeface Interstate designed by Tobias Frere-Jones).

1.6 Summary and conclusion

To meet the problem of lost details at great distances, serifs on the vertical stems improve distance legibility, yet when the type is influenced by halation, or in situations where light is projected from the back of the sign, the

letters might benefit from being designed as low contrast sans serif fonts instead.

Open inner counters generally tend to improve distance legibility; this can be achieved by making the x-height relatively large and the letter shapes relatively wide. That being said, there is a limit to the size of the x-height if certain glyphs are not to be misread for others, and there is a limit to the letter width, if the text is to fit horizontally on a specified surface area without having a point size that is too small.

Due to the effect of crowding, it further appears that large inter letter spacing – in general – benefits distance reading, and that this is most evident when light text is placed on a dark background. Furthermore, since the color white tends to bleed into a darker surface, text set white on a dark background should be lighter in weight than the corresponding dark text on a light background.

A practicing designer's knowledge and understanding of the craft is often attained through trial and error, or through experimentation with the material, while scientific findings often stem from controlled investigations that aim to either confirm or disconfirm a predefined hypothesis. By combining these distinct approaches, and by considering them as equally valid in the search for answers, it is possible to gather information that can help us better understand the field of type design.

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