research question:

which is more legible, sans serif or serif?

past method:

compare two different typefaces (example) –

one sans serif - Helvetica
one serif - Times

results:

inconclusive

improved method:

compare one typeface in two versions,

Lucida sans serif
Lucida serif

results:

serif version in smaller sizes resulted in slower reading rate

(Morris el al. 2002)

Letterform Research: an academic orphan

Sofie Beier

Abstract

This paper looks into the history of letterform research and discusses why the discipline has yet to make the big break within design research. By highlighting two of the most popular focus areas (letter distinctiveness and the role of serifs) and by discussing various forms of methodological shortcomings, the paper suggests that future research into letterforms should (1) draw on results from the field of reading research (2) be based on test material informed by design knowledge and (3) move away from the former tendency of looking for universal answers.

Keywords

design research, research methods, legibility, readability, typography, design

Introduction

At the early days of the journal *Visible Language*, initially *The Journal of Typographic Research*, the journal made a substantial effort in trying to inform the design community about relevant research findings on typography. At its tenth issue, the editor Merald Wrolstad (1969) reflected on the state of letterform research, finding the field flourishing in as different areas as psychology, education, engineering, highway safety, cartography, and many more. However, in relation to the typographical community, Wrolstad saw that letterform research was what he called an 'academic orphan' as it did not have an established academic home. The downside of this, he argued, was that the direction and progress of the research was completely dependent on other disciplines and that those disciplines focused on research problems related to their own area of interest and were not looking at letterforms per se, which is what is relevant for the design community.

Six years on, learning theorist Michael Macdonald-Ross and designer Robert Waller (1975), published a critical paper, which thoroughly explained why they believed designers did not benefit from the findings generated in the field of legibility research. In a review of some of the most influential studies of the early 20th century (e.g. Pyke, 1926; Paterson & Tinker, 1940; Luckiesh & Moss, 1942; Burt, 1959; Tinker, 1963), Macdonald-Ross and Waller identified a number of flaws or 'systematic defects' as they called them.

One such flaw was that it was difficult to see the day-to-day relevance in some of the most popular experimental questions. Here the authors criticized the tendency among researchers to choose topics that are easily tested in a laboratory setting, instead of looking into the problems that typographers face in practice. They further raised the problem, which has also been mentioned by other critiques of legibility research (Lupton, 2003; Lund, 1995; Sless, 1981), that it is impossible to isolate one variable as typographical variables always interact. Additionally, Macdonald-Ross and Waller criticized the fact that many experiments are presented in journals without reproduction of the test material, which makes it difficult for the reader to judge whether other variables might have influenced the findings. To suggest a more fruitful direction, Macdonald-Ross and Waller recommended that legibility researchers make greater use of the tacit know-how of designers.

15 years later, Robert Waller (1990) continued the discussion in his paper "Typography and Discourse" where he complimented the work of Herbert Spencer and colleagues at the Royal College of Art for combining the skills of psychology and design and for the fact that their studies had relatively modest and realistic goals.

Established in 1966 and continuing for 16 years, Herbert Spencer's Graphic Information Research Unit, initially known as the Readability of Print Research Unit, focused among other topics on how various forms of reproduction methods affected the legibility of type and layout. In the 60s and 70s, relevant areas to look into were poor quality printing and the effect of show-through, photocopies and thinning-down or thickening-up of the type, microforms, and videotext displays. In addition to this, the group also worked with matters of directional signage and labeling at libraries and museums (Reynolds, 2007, 1979). What characterized the research direction was that their work was funded externally from organizations such as the British Library and The British Post Office. These organizations had specific questions they wanted answered. Combined with the fact that several members of the group had a background in design, it likely made the work easily transferable into real life design situations. This way of working was atypical for the time. 20th century legibility researchers often had a background in psychology or engineering, and their work was driven by an aim to identify a set of universal rules that could be transferred into any typographical situation or context.

A popular research topic was to test a number of different typeface styles, and rank them according to the most legible (for examples see Tinker, 1944; Pyke, 1926; Roethlein, 1912). There are several problems with such an approach. First the findings only inform us on the relationship between these specific typefaces, and teach us little about any other typeface styles; second, different test methods produce different findings and third the results of testing one reading situation cannot always be transferred into another reading situation, as put by typography writer Walter Tracy in the 1980s:

> As some academic writing shows, the absence of practical experience of type gives rise to a tendency to treat all types as equal and similar in nature, purpose and function. In short, there is a failure to recognise the different roles of type faces (Tracy, 1986, p. 27).

The early researchers investigated the affect of various typefaces on reading, without necessarily drawing on relevant knowledge on typography (for more on this see Beier & Dyson, 2014). Greater awareness of the perceptual and cognitive aspects would have provided the researchers with useful clues on more prolific topics to investigate, instead of repeating the same form of studies again and again. Today, the focus of the majority of reading research still lies within the field of psychology; however, the main area of interest has over the years moved away from the comparison of typeface style, size, and layout to a focus on the cognitive mental processes that lies behind the action of reading, with focus areas such as: dyslexia, the process of word recognition, eye movement, and how to teach reading. Neither the early approach of an often uninformed focus on typographical matters nor the present approach of solely looking into the cognitive process of reading are ideal for producing findings that can fully enlighten the typographical community. In that sense, the problems raised by editor

Merald Wrolstad almost half a century ago are still problems. It can hence be argued that the discipline of letterform research within design is still an academic orphan, with relatively few researchers having designers as their main target audience.

Another possible reason for the discipline's lack of appropriate development might be related to designers over the years having a general lack of interest in the topic. In his book *The visible word* from 1968, Herbert Spencer stated, "Some typographical designers and printers shun legibility research because they regard it as a threat to their freedom of action" (Spencer, 1968, p. 6). Later in 1999, typography writer Rick Poynor described a meeting with a couple of London designers. The duo was devoted to the Swiss school of typography and explained to Poynor that they rarely read the text they laid out. Poynor went on to express his personal dislike with reading text set by this team of designers, finding their typography hard to read and uninviting. Based on his own observations, Poynor concluded, "type designers and typographers have poured scorn on the very idea of legibility" as "the scientific approach seems fundamentally hostile to the mysteries of the creative process" (Poynor 1999, p. 14). Other designers are well informed about the scientific findings, however choose to ignore them. One such example is designer Jason Santa Maria (2014). In an attempt to explain the mechanism behind the reading process, Santa Maria presents several theories as being valid in spite of these same theories being disproven by research. In the comment section, Santa Maria recognizes this yet explains that regardless, he finds the theories he presents most compelling.

In 1981, *Visible Language* published a special issue on *Visual Cues in Word Recognition and Reading*, which was edited by psychologist Keith Rayner. In the introduction, Rayner concluded that research into the visual factors involved in reading, often has not involved much communication between researchers interested in reading and the graphic designers who set text to print (Rayner, 1981, p. 125). As he acknowledged that none of the authors of the issue had a background in design, Rayner found that several of the papers had a direct relevance to designers, with their focus on eye movement and the visual cues that may influence reading. In more recent time, several publications have also aimed at informing the design community about relevant research findings on the visual processing of letters and words (Thiessen et al., 2015; Beier & Dyson, 2014; Lonsdale, 2014; Dyson, 2013; Beier, 2012), and a number of other publications have aimed at informing psychologists and vision scientists on the role of typography matters in reading (Keage et al., 2014; Sanocki & Dyson, 2012; Legge & Bigelow, 2011). Furthermore, several of the larger commercial organizations working with digital technology have lately shown interest in implementing reading-related scientific findings in their products. Among these, the reading mode for Microsoft's OneNote (Chansanchai, 2015), which has added new functions for syllable marking, syntax marking, and crowding reduction, all based on data from the reading psychology community. Such usage of reading research opens up for a deeper relationship and collaboration between researchers from the fields of psychology and design.

To continue this positive development, and to expand the discipline and move away from the status as an academic orphan within design research, it is essential to give space to both applied and basic research. While applied research can produce findings that can be implemented directly in new designs, basic research can continue to focus on the cognitive processes of reading and hence produce the necessary findings for the applied research to be able to ask the right research questions.

As earlier mentioned, different test methods produce different findings, as is demonstrated in the legibility ranking of a range of typeface styles by Miles A. Tinker in 1944. Instead of viewing this as an indicator of the shortcomings of legibility studies as a whole, it proves the notion that different reading situations put different demands on the typefaces applied. For example, type viewed in the center of the visual field at great distances tend to blur (Liu & Arditi, 2001; Hess et al., 2000) a phenomenon called crowding, or counter interaction; the same is seen in type viewed in the peripheral part of the visual field (Pelli et al., 2007; Chung et al., 1998; Bouma, 1970) as is the case in running text. Furthermore, running text typically presents a greater number of letters to the reader at once than do type for signage. All these, and many more factors, influence the legibility of a typeface in different ways. It is therefore not possible to identify the best legible typeface or the best way of testing legibility. Keeping in mind that when designing experiments that target specific typographical questions, it is essential to choose test methods that relate to the reading situation under investigation. In other cases, where the question relates to a more fundamental understanding of the process of reading, the various methods of short exposure might be more appropriate, as these methods tend to have a greater sensitivity to variations in the performance of participants.

Next, we will take a closer look at two of the most popular focus areas within letterform research and reflect on what we know and how to approach the discipline to further minimize the methodological shortcomings in the future.

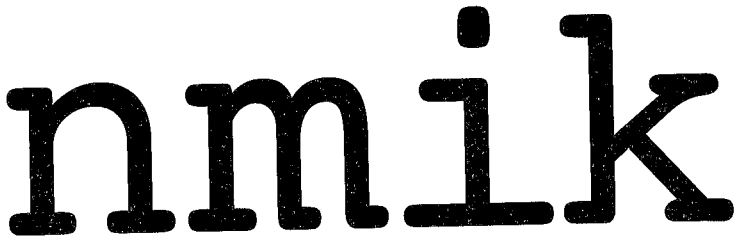
Letter distinctiveness

A popular research topic of the 20th century was to identify the most common misreadings between different letter pairs within a specific typeface (Mueller & Weidemann, 2012). A comparison of some of these findings (Beier, 2012) demonstrates that different typefaces result in different forms of misreadings. As an example, the typeface Courier results in frequent misreading between 'n' and 'm' (Bouma, 1971), while the same is not the case with the typeface Futura (Geyer, 1977). The obvious explanation for this is that due to the monospaced features, the Courier 'm' is much narrower than

the same letter in other typeface. The misreading likely occurred because participants expected the letter 'm' to be wider than the letter 'n'. The typeface Courier is further designed with large dominant slab serifs, so it may be that these could have influenced the identification of letters in ways that would not happen in typefaces of less dominant serifs (Figure 1).

Figure 1

The typeface Courier is monospaced, which means that the letter 'm' is unusually narrow and the letter 'l' is unusually wide.



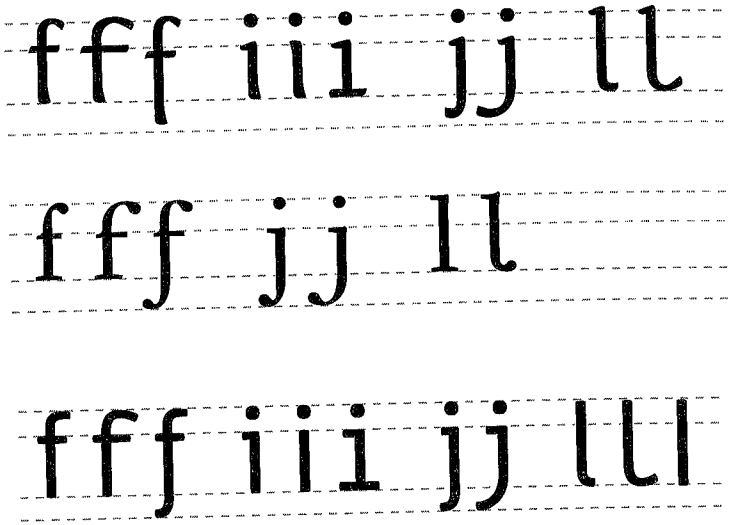
A collective examination of the findings, do, however, indicate a greater misreading between lower-case letters of no extenders ('e', 'c', 'a', 's', 'n', 'u', 'o'), lower-case letters of narrow width ('i', 'j', 'l', 'f', 't'), upper-case letters of round features ('O', 'Q', 'G', 'C', 'D'), upper-case letters of diagonal strokes ('X', 'Y', 'K', 'V'), and upper-case letters of vertical strokes ('M', 'N', 'H') (Beier, 2012). Such observations come as no surprise as these letters groups also contain the letters of the alphabet that have the most attributes in common. Fiset and colleagues (2008) have confirmed the notion in demonstrating that when identifying individual letters of the typeface Arial, readers focus on the attribute of the letter that separates it from other visually related letters, such as the cross bar of the 'e' making it different from 'c' and 'o', and the space between the dot and the stem of the 'i' making it different from 'l'. However, to sufficiently inform the discipline of letterform research, none of the above-mentioned studies can stand alone, as they only look at the matter by testing one typeface style. It is therefore difficult to say whether the findings are transferable to other typeface styles as well.

Fox and colleagues (2007) have tested the legibility of the lower-case letters, numbers, and symbols of 20 different typefaces. Applying a method of short exposure, where the characters were displayed in 10-point font size, the researchers found that the letter 'e' of the typefaces that had a crossbar placed up high, was less legible than the typefaces where the letter 'e' had a crossbar placed in the perceptual center. To compensate for the differences between typefaces, features such as x-height, letter weight, and stroke contrast were each treated as independent factors in the analysis.

Another way of meeting the methodological shortcomings of the comparison of different typeface styles is seen in a study by Beier & Larson (2010), testing different letter variations within the same typefaces (Figure 2). By applying such a method, it should be easier to isolate specific variables for investigation. The study in question found that for distance reading, the identification of individual narrow letters is improved when letters are designed with wide shapes, that a one-storey 'a' is less legible

Figure 2

Letter variations within three different typefaces (from top) Spencer, Pyke and Ovink, designed by Sofie Beier. The study found that at distance reading, wide versions of narrow letters were read at greater distances than narrow versions (Beier & Larson 2010)



than a two-storey 'a', and that a curvy spine of the letter 's' appear to be more legible than a diagonal spine. The investigation included 2-5 variations of each of the tested letters within the typefaces. To fully explore the matter of letter distinctiveness, upper-case letters should be investigated as well as other kinds of lower-case letter variations. Further, only two test methods were applied, one measuring the maximum distance of identification and one measuring the identification in the peripheral view of short exposure. A focus on identifying the most legible letter-skeleton for different reading situations is a huge area within letterform research that will benefit from more research based on suitable methodologies.

In a thorough review of exiting research that apply psychophysical techniques in the study of letter perception, Grainger and his colleagues (2008) concluded that there is convincing evidence suggesting that letters are identified via their component features. The majority of research into understanding reading further indicates that we read in a parallel operation of a bottom up process of the identification of the individual features and wholes of the letters and of a top down process where we draw on a mental lexicon of syllables, words, and sentence structures that we have encountered before (McClelland & Rumelhart, 1981; Rumelhart & McClelland, 1982). Such research produces the theoretical background to direct letterform research towards identifying the most differential letter features; however, it further opens up for a second focus area of maximizing the legibility of the letters in combination within words and sentences. A relevant angle would be to study the regularity-effect (Sanocki & Dyson, 2012). The phenomenon identified as font tuning (Dyson & Beier 2016; Walker, 2008; Gauthier et al. 2006; Sanocki, 1991, 1992) finds that readers tend to "tune into" the specific features of a given typeface, which makes it easier to read text set in one typeface instead of a mix of typefaces. This indicates that characters within

a typeface need to share a common foundation for readers to tune into the type. Future studies that focus on the balance between letter distinctiveness and letter and word regularity would greatly contribute to the field of letterform research.

Recently, cognitive psychologist Kevin Larson and type designer Matthew Carter published parts of the substantiated experimental research carried out in relation to the development of the typeface family Sitka (Larson & Carter, 2016). More than aiming at producing scientific findings, the focus of the project was to inform the design of the typeface family Sikta. As part of the design process, the research group studied participants' recognition of different character variations when presented at short exposure on screen. The stimulus was displayed both as single letter and as the middle letter in a sequence of three letters. Among the findings, the research group showed that open counters of letters such as 'a', 'e', 'c', and 's' perform better when flanked by others and that narrow letters like 'f', 'j', and 'i' produce different misreadings depending on whether they are flanked by other letters or are presented in isolation. This difference in performance between letters presented in isolation and letters presented in groups could benefit from further research as well.

ans serif and serifs

Another highly popular research topic is to try and settle the dispute of whether sans serif or serif typefaces are the most legible. In his PhD thesis from 1999, Ole Lund identified 72 studies on the matter, where the majority was published in the 20th century. The approach in the past has typically been to compare two different typefaces, say Helvetica and Times Roman, and then, based on this comparison, make an overall conclusion about the role of serifs on letterforms. The validation of such comparisons is obviously difficult to defend as two different typeface styles often vary on so many other aspects than just the serifs. In a valid study of the influence of serifs, the serifs consequently should be the only difference between two tested typefaces. This matter was taken into consideration when *Visible Language* in 1971, published the paper "Why Serifs are Important" (Robinson et al. 1971). The test stimuli were dot matrix letters in two sizes, with a version with serifs and a version without serifs. In the small sizes the two variations only varied on the presence or absence of serifs, while the serif letters in the larger size had a higher stoke contrast than the sans serif letters. The serifs were, however, on all letters highly exaggerated. To identify the function of serifs, the authors employed a computer model, which they argued simulates the human visual system. By processing the letter stimuli through the computer software, the researchers concluded that "serifs perform an important function in preserving the original image of a small letter in a perceptual system with horizontal and vertical line detectors" (Robinson et al. 1971, p. 358). Viewed in a historical perspective, it is evident that the researchers overstated the computer's ability to simulate human perception, and as later argued by Lund (1997) the study appears to be built upon a "chain of theoretical assumptions while purporting to rely on physiological facts" (Lund 1997, p. 93). The interpretation of the findings was hence somewhat dubious.

In 2002, mathematician Robert A. Morris and co-authors looked at the speed of reading sans and serif typefaces by a method of Rapid Serial Visual Presentation. One of the authors was the type designer Charles Bigelow. For the study, Bigelow and Kris Holmes had designed new versions of the typeface family Lucida (Figure 3), with one major variation between the two tested fonts being the presence or absence of serifs. The stimuli were in two sizes, 40 pixels and 160 pixels. With participants placed at a 4 meters distance from the screen, the study showed that the serif version of Lucida in the small size resulted in slower reading rate, with no difference at the larger size. By applying test material originating in the same typeface family, the researchers ensured that the findings are related to the serifs.

Figure 3

Designed by Kris Holmes and Charles Bigelow, these variations of the typeface Lucida were developed for the investigation, so that the main difference between the two styles lies in the presence or absence of the serifs (Morris et al. 2002).

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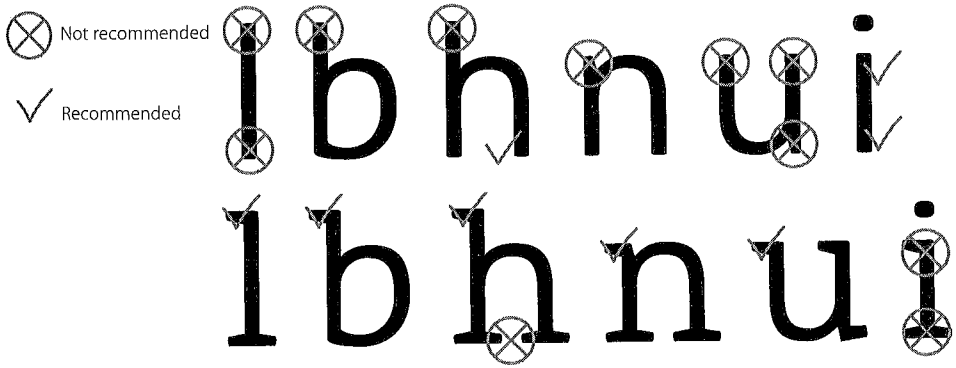
More recently, *Visible Language* published yet another paper on the topic of serif legibility (Beier & Dyson, 2014). As in the study above, the test material was designed within the same typeface family so that the only difference between the two tested typefaces was the presence or absence of serifs. However, instead of investigating the overall effect of serifs, this study focused on the effect serifs have on distance recognition of letters in isolation and found that under such reading conditions, serifs

Figure 4

Beier and Dyson (2014) found that serifs on the vertical extremes tend to improve distance legibility of single letters.



play a positive role when placed on the vertical extremes (Figure 4, above). This finding is interesting in that it opens up the idea that the effect of serifs might vary depending on their placement on the letters, and hence hybrid typefaces mixing elements from sans serif and serifs styles could be beneficial under certain reading conditions. It is here worth noticing that the study by Morris and colleagues that found serif letters in small point sizes to cause slower reading, was based on word representation, while the study by Beier and Dyson that found higher recognition of some serif letters, was based on single letter representation. It could be that serif typefaces when set in words are more affected by visual crowding than sans serif typefaces. An interesting question is how the serifs on vertical extremes will perform when the letters are tested in words and how Lucida with serifs will perform if tested with a wider spacing setting or with the letters in isolation. Further, the Beier and Dyson study only looked at the lower-case alphabet; how do serifs affect the individual legibility of the upper-case alphabet? Future studies focusing on such questions would greatly contribute to the discussion of the serifs' function.

nclusion

It appears that the infrequent collaboration of scientists and designers is the main reason why letterform research has suffered as an academic orphan. Although the lack of typographical understanding has resulted in methodological shortcomings in the past, the diverse contribution of knowledge from different research traditions has in fact let to the development of better experimental approaches.

By presenting findings that can be applied in practice, a number of recent studies indicate a positive development by finding that 1) certain letter skeletons will lower the legibility of the letters, 2) flanked letters have different influence on the legibility of letter skeletons, 3) serifs slow down reading rate when words are viewed at distance in small point sizes, and 4) serifs placed at the vertical extremes improve legibility when letters are viewed in isolation at distance. As there is no universal answer that can be attributed to all reading situations, these studies focus on relative narrow research questions, which collectively, can contribute to the overall understanding of letterform research, and individually, can focus on the details under investigation.

To produce findings that are relevant for the practicing designer, scientists benefit from consulting designers in the development of the experiments. While designers can contribute with design skills, they cannot always contribute with scientific rigor. Hence, researchers will profit from adopting a methodological approach that ensures both control of critical typographical variables and scientific validation. An interdisciplinary collaboration where scientists provide valid test methods and analysis and designers identify relevant research questions and develop test materials, will enable a project to reach more informed findings than what the two fields would be able to produce in isolation. Through such interdisciplinary collaborations, letterform research will be able to grow out of its current identity as an academic orphan, and develop into a full member of the academic research society.

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