Typography in Human-Computer Interaction
Cognitive and aesthetic implications of typeface selection and presentation

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Typography is the art of laying out text for print or on screens for aesthetics and for readability. It concerns the use of different font faces and sizes and layout constraints such as line height, column width, kerning, and colors. Typography has been around for thousands of years, from stone tablets to illuminated manuscripts to Gutenberg to the GUI. In the context of human-computer interaction, typography has critical importance in a number of applications. The primary purpose of a great deal of software is to provide access to textual content. Additionally, instructions, labels, and navigation for applications are presented in text, and must be readable in order for users to have successful and efficient interactions with the application. Our study looks at typography through the lens of the cognitive psychology literature, namely how different typographic choices made by application designers affect the visual perception, readability, and comprehension of the materials. We are interested in what the scientific inquiry tells us about how we can use typography to improve human-computer interactions.

Before delving into the research, we will define a few of the key typographic terms used throughout. Font face or style describes the overall letterform, for example Arial or Times New Roman. Font faces may have serifs (the extensions at the end of the letter, such as in Times New Roman) or may be sans serif (lacking serifs, such as in Arial).

![Fig. 2 - Font Types](image)

Fonts may be display fonts, designed for headlines, or text fonts, designed for large bodies of smaller text. When measuring font size, there are two measures: the body size, which measures the full height of letters, from the bottom of the descenders to the top of the ascenders and
additional gutter space above and below; and, the x-height, which measures only the height of the lowercase x, from the baseline on which the text rests to the top of the x. Ascenders are parts of lowercase letters that extend above the x-height; descenders are parts that extend below the baseline. The following graphic from Poulton (1972) summarizes the key parts:

![Typeface Anatomy](image)

**Fig. 2 - Typeface Anatomy**

**Research Summaries:**

The literature on typography begins in earnest with the studies of Tinker and Patterson who published a number of articles on the legibility of printed text between the 1920s and 1950s. Tinker and Patterson found important results including a relatively minimal effect of font face on legibility among common text fonts (1932), that greater luminance contrast improves legibility (1931), that larger text is more legible to a point (1929 Study II), and that, due to saccade length when scanning, there is an optimal column width for text of around 80mm (1929 Study III). As Tinker and Patterson’s work reflected the legibility of printed text, research into the perception of typography in relation to human-computer interaction would have to re-validate many of their points (while finding some discrepancies); however, the principles they have found have held up remarkably well in the HCI domain.

Taking into account the history of typography and the changing face of type for electronic display, Boyarski, et al. (1998) studied the varying features of legacy fonts and modern typefaces
designed for electronic display. While this study was not designed to determine which fonts were better than others, it does offer a scientific way to discern which features of new typefaces allow for them to be more easily read on screen.

The Boyarski study utilized 48 participants in an academic setting who were tasked with a Nelson-Denney Test of college-level reading comprehension in one of three fonts -- two designed specifically for computer display and one designed before the advent of electronic displays. In part two of the experiment, the effects of anti-aliasing, or smoothing of a display font, were explored. A speed reading test was utilized for part two of the study, in which two fonts were compared to each other and their anti-aliased counterparts.

In both portions of Boyarski’s study, participants exhibited preferences in typeface based on perceived differences in legibility, with participants finding typefaces designed for screen display with anti-aliased characters more legible. These results were statistically valid, and demonstrate a clear user preference for modern typefaces. Further aiding the legibility of screen displayed characters, the evolution of display technology has helped proliferate font anti-aliasing, and its increasing use by designers helps create legible, usable computer interfaces.

Building on the work of Boyarski and others, Beymer et al. (2008) continue to tackle the question of which font faces and size are the most legible for screen viewing. Subjects were asked to read a one page passage from a science journal at an 8th grade reading level. In the first task, participants were tested in varying font size conditions (10pt, 12pt, and 14pt). In the second task, participants were tested in varying font style conditions (sans-serif Verdana and serif Georgia).
Beymer’s study differed from much of the previous research in legibility of typography in the manner chosen to operationalize legibility. The study utilized eye-tracking hardware to measure first-pass reading speed, regression rate, time in return sweeps, fraction of the material re-read, saccade length, and fixation duration. Although Tinker and Patterson performed some eye-tracking studies, most legibility studies (like Boyarski’s study above) have used some form of measure of recall, retention, and understanding of the content to measure legibility. The eye-tracking method provides more insight into physiological behavior, whereas measuring reading speed and comprehension can tell us about the results of that behavior, but not how those results were achieved.

In the font-size test, they found significant differences in the time of return sweeps (slower for larger fonts) and in fixation durations (longer for smaller fonts). The return sweep result can be explained because the number of words on the line was constant through the tests, so the larger font size resulted in a larger line to scan. The experimenters suggest that it is the increased fixation duration in the smaller fonts that accounts for improvements in legibility for larger font sizes.

In the font-type test, they found no significant differences, which is consistent with other work in the area, which generally has not shown a significant benefit for either type of font. If you consider the role of processing word shapes when reading rather than processing letters individually (Broadbent and Broadbent 1980), than the ability to distinguish ascenders and descenders would be one of the most important characteristics in determining legibility. Therefore you would not expect to see major differences in legibility between most text fonts, serif or sans serif, with recognizable letterforms.
Practical implications for this study suggest that the choice of serif versus sans-serif is less important than choosing the font size. Choosing a larger font size is largely more legible; however, when choosing larger font sizes you must consider the line width, as longer line widths are more difficult to read.

Humar, Gradizar, and Turk (2008) investigated the role of text-background color combinations in reading text from a CRT screen to understand the effect of contrast on readability. Previous research on the topic has focused on contrast using ink and paper. Because screen colors in screen displays are built using additive colors as opposed to subtractive colors in ink on paper the results of those studies may not fully apply to human-computer interaction. Additionally, while previous studies on the topic have covered a limited number of color combinations, this study reviewed 56 different color combinations.

The results agreed with previous research showing that higher luminance contrasts resulted in better legibility. Some variations from previous findings using ink on print have applications for human-computer interaction. One finding was the polarity of the contrast had a significant effect on legibility. (Polarity refers to whether the text or background has the higher luminance. Black text on white has positive polarity; white text on black has negative polarity.) In the highest contrast groups, negative polarity showed better performance than positive polarity. Additionally, several color combinations, including cyan on magenta and green on red, performed significantly worse than expected by their contrast ratios. The authors suggested that these color combinations may cause visual strain on a CRT. These results also indicate that the medium of display (CRT versus paper versus LCD) make a difference in the best color choices for contrast.
Fig. 3 - Color Contrast

An excellent compliment to Humar, et al. are the legibility studies of Greco, et al. These studies investigate text-background color combinations and their effect on presentation legibility and pleasantness. The authors were perplexed by the illegible projected presentations of architects, designers, and visual scientists -- people, who, by all accounts, should know better than to use illegible color combinations. The authors take a three-pronged approach to experiments, using slides of varying text-background colors on a laptop, via video projector, and finally asking participants to rate legibility and pleasantness directly.

The experiments used in the text-background color studies featured a mix of men and women with normal color vision. In all cases, subjects viewed PowerPoint slides with combinations of light and dark text on similarly light or dark backgrounds, totaling 702 combinations. In the first trial participants rated legibility on a scale of 1 to 3, rated pleasantness of these combinations in the second trial, and viewed the most legible and most pleasant combinations of text and background in a room with varying light conditions. The results of the experiments showed that, in presentations, dark text on light backgrounds is the most legible, dark text on light backgrounds also rated as the most pleasant, and that pleasantness strongly correlates to legibility; or as Greco, et al. put it: “If the rule of thumb is ‘What’s beautiful is also legible,’ this should be changed into ‘What’s legible is also beautiful.’”

Unlike the other studies we encountered, the Greco study is a direct analysis of a phenomena many people can probably 'feel' but have never put much thought to. Indeed,
computer users are bombarded with text-background color combinations daily, and will avoid use of computer resources that do not conform to their ideal of pleasantness and legibility.

All of the research we have looked at to this point has focused on the effects of legibility of characteristics such as font face, font size, color, and spacing. Li and Suen (2010), however, attempt to understand the personality traits that different font faces represent. The authors selected 24 commonly used font faces including Times New Roman, Arial, Harrington, Cooper Black, Jokerman, and Harry Potter and asked participants to rank each of the font faces on ten different personality traits commonly used to describe fonts in previous research.

Based on analysis of the survey results, fonts were divided into groups representing four personality factors: directness, gentleness, cheerfulness, and fearfulness. Li and Suen then analyzed typographical characteristics of the fonts based on the personality factors. Fonts in the directness group were rated most legible. Gentleness fonts had the highest x-height proportion (as a ratio of the full letter height), and directness and cheerfulness fonts had similar ascender and descender ratios. Gentleness fonts had slightly higher weights than directness fonts; fearfulness fonts had the smallest weights. Directness and gentleness fonts rank similarly on aesthetic traits such as elaborateness, ‘geometricness’, and symmetry.

The decision of which font to use based on personality is important in the context of emotional design, but has been largely left to aesthetic considerations. This study shows that certain fonts are subjectively perceived to have certain traits. While Li and Suen’s attempts to link those personality traits to characteristics of the font had limited success, this study offers a good start to begin to understand that characteristics that make up the personality of a font.
Future Direction:

The results of our research can be put to immediate use by application developers to improve the readability of their applications. Some basic recommendations would include:

- Choose a common font with recognizable letterforms for large bodies of text
- Use a font size of at least 10-14 points
- Present blocks of texts in column; don’t let text span the entire length of the screen on a wide screen display
- Choose text and background colors with a high luminance contrast

Future research in typography as it applies to HCI has multiple avenues for further study, but in the context of our interests one promising direction for future work is a study into the holistic results of combining the recommendations shown by the reviewed research. Rather than continued experimentation on individual variables, we believe it would serve to combine suggestions that arose from initial studies and see if together the optimization of font, color, and design elements work to improve reading comprehension, passage legibility on screen, or overall experience for the user.

A second direction of further study calls into question some findings of earlier research when applied to the growing market segment of mobile computing devices. Small, mobile screens are exceedingly different from the large CRT, LCD, and projector screens used in the studies we profiled, and research has shown that the medium text is displayed on can affect the typographic characteristics that offer the best legibility. The typefaces used on mobile devices must balance legibility and the user experience with both the hardware characteristics of mobile computing devices (such as significantly smaller screens, though often with highly increase pixel density) and the physical characteristics typical of operating in the mobile context (using the devices on-the-move, operating in bright sunshine, etc.). We believe that the application of
suggestions offered by the above researchers in a mobile context that differs from the
workstation and presentation contexts studied above so significantly could help shed light on the
mechanics of mobile device use as well as the cognitive factors involved in mobile computing.

To accomplish future research goals, any studies in the field that attempt to address both
the concerns of the mobile device user and combine the suggestions of previous research will
have to be designed that utilize the smaller, limited-resolution screens common on today’s
mobile devices and use contemporary fonts, like Google’s Droids Sans and Apple’s Lucida
Grande, to achieve meaningful results. We propose the prototyping of mobile device user
interface elements, and implementing multiple versions and combinations of font and
background color to analyze the factors influencing content retention, presentation, and legibility
as our profiled studies did. Such studies will reveal much about the nature of mobile computing
typography needs, and can only serve to improve future product and user experience.
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