

# PseudoSloan: A perimetric-complexity and area-controlled font for vision and reading research

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Artificial orthographies have long been used in studies of verbal learning and reading. These orthographies, also known as pseudo or false fonts, are designed to match the letters of an existing alphabet on a range of visual features, isolating effects of orthography from those owing to lexical processing. In a parallel line of research, there has been much interest in the design of optotypes for measuring visual acuity that have good properties in terms of character complexity and graceful degradation under blur. Here we merge these two traditions by designing a fully scalable pseudofont, “PseudoSloan,” that is based on the design rubric of the widely used Sloan optotypes. The font includes 26 Latin letters as well as two sets of letter-like symbols matching the Latin alphabet on a letter-by-letter basis. Quantitative matching of the pairs of Sloan and PseudoSloan glyphs is done on the basis of ink area and perimetric complexity. We provide the installable PseudoSloan font in TrueType and OpenType formats, plus a large number of PseudoSloan glyphs in .svg format that vary over wide ranges in their perimetric complexity and ink area (<https://osf.io/qhj2b/>).

## Introduction

Written symbols are critical visual forms that mediate the reading of text, and their recognition is thus an essential part of modern life. There has been much interest in visual processing of letters in the case of alphabetic languages and of idiograms

in non-alphabetic languages. Letters were first used to measure visual acuity by Kuechler in the mid-nineteenth century (cited by (Colenbrander, 2008). Kuechler’s chart, reproduced in Colenbrander (2008), comprised single words per line of decreasing size. The words were rendered in a complex Fraktur typeface. Subsequently, Snellen introduced several innovations (Colenbrander, 2008): the use of specially constructed serifed “optotypes” designed for acuity measurement, the arrangement of letters rather than words into the familiar chart form, and calibration of letter size to units of visual angle (Colenbrander, 2008). Louise Sloan (Sloan, 1951) pointed out that the use of serifs may produce unfamiliar, difficult to recognize forms, subsequently introducing sans serif optotypes based on Snellen’s 5 × 5 grid and equal black and white stroke widths (Sloan, 1959). Optotypes have become the preferred means of clinical acuity measurement as their recognition is a familiar task, at least to literate patients, and depends strongly on the quality of refraction, the most common source of decreased visual acuity.

Reading involves acuity, orthographic, and lexical processes. With the advent of functional neuroimaging, the reading literature has made important use of letter-like symbols—“false-fonts” or “pseudofonts”—as a means of studying the visual processing demands of reading separate from semantic content. Importantly, the space of letter-like symbols used in many writing systems is relatively limited as characters of many writing systems tend to have approximately three

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strokes (Changizi & Shimojo, 2005) and the complexity of characters does not depend strongly on the number of characters used in the writing system (Changizi & Shimojo, 2005; Miton & Morin, 2021).

The design of these pseudofonts conserves essential features of the native font, while at the same time avoiding combinations of features that are graphemes in the alphabet under study. Pseudofont creation has been accomplished in a variety of ways, for example, “The false-font font characters were composed of compositions of contiguous curved and straight-line segments designed to be at once dissimilar from any of the alphabetical symbols, but equivalent in the content of primitive features” Petersen et al. (1990) or “The false fonts were created by recombination of letter elements (ascending, descending horizontal, and curved lines of the font type Arial” (Indefrey et al., 1997), or “Finally, false-font strings (category 1) were generated using a custom-designed pseudo-font with fixed character spacing, where each uppercase letter was replaced by an unfamiliar shape with an almost equal number of strokes and angles and an overall similar visual appearance (Vinckier et al., 2007). More recently, a rubric based on equating strokes, junctions terminators and symmetry between the pseudofont with letters of the Latin alphabet (Courier New font) has been used to create the Brussels Artificial Character Set (BACS) stimulus set (Vidal, Content, & Chetail, 2017), which is available as an installable .otf font <https://osf.io/dj8qm/>.

The previously described pseudofonts differ in their construction rules and thus the equivalence to letters of the alphabet to which they are to be compared. Moreover, the details of the construction rule may vary over different fonts used to render a particular alphabet. An important question is thus how to assess the equivalence of a given font and its corresponding pseudofont quantitatively. A key concept in both the acuity and reading literatures is the notion of legibility. Legibility depends on stimulus contrast, letter size, spacing, and stroke width, as well as character complexity (Bigelow, 2019; Loomis, 1990). Complexity has been quantified by a simple metric—perimetric complexity, which is an empirical measure proportional to the ratio of the squared perimeter of the shape and its area (Arnoult & Attneave, 1956; Pelli, Burns, Farell, & Moore-Page, 2006). Perimetric complexity provides a good description of the efficiency of character identification over a wide range of character types and fonts (Pelli et al., 2006) and we thus chose to use perimetric complexity, along with ink area, as a means to quantitatively equate glyphs used to match letters of the Latin alphabet. Motivated by a desire to link the visual acuity and reading literatures through the use of optotypes that can be varied in size and specified complexity, here we describe the PseudoSloan font, its design principles and the corresponding downloadable .otf and .tff fonts (<https://osf.io/qhj2b>).

## Methods

### Pseudofont construction

The Sloan letters (Sloan, 1959) are based on a  $5 \times 5$  square grid, as illustrated in Figure 1. The thickness of the lines equals the thickness of the white spaces and also the thickness of the gap in the letter “C.” The height and width of the optotypes is five times the thickness of the line. In addition to the  $5 \times 5$  grid, there are two sizes of inscribed circles, portions of which are used to compose letters with curves, such as the letters B, C, and D. A font for the Sloan letters authored by Denis Pelli has been available for a number of years <https://github.com/denispelli/Eye-Chart-Fonts>.

The design language of the Sloan letters admits the creation of a large number of alternative glyphs. Using this design language, we created 26 Latin letters and a set of 264 candidate artificial glyphs by hand using Adobe Illustrator and OminiGraffiti software. Using high-resolution vector representations in SVG format, we computed perimetric complexity and ink area of all Latin letters and candidate glyphs, and then selected two sets of artificial glyphs matching each Latin letter in both the complexity and the area simultaneously. When pseudofonts are used to measure neural responses, it is important to control the ink area, because this factor affects the luminance of the stimuli. Equating the mean luminance of the font and pseudofont stimuli ensures that luminance does not inadvertently drive the response.

Perimetric complexity (Watson, 2012) can be defined for binary images such as letters as the sum of the inside and outside perimeters of the foreground  $p$ , squared, divided by the foreground area  $a$ , divided by  $4\pi$ , or  $c = p^2/4\pi a$ . Figure 2 shows examples of the perimetric complexity of geometric shapes and some letters typeset in different fonts. Figure 3 shows a subset of the candidate glyphs, with glyphs highlighted in black being glyphs selected for inclusion in the PseudoSloan font.

Figure 4 shows the ink area and perimetric complexity of the preliminary corpus of 264 glyphs

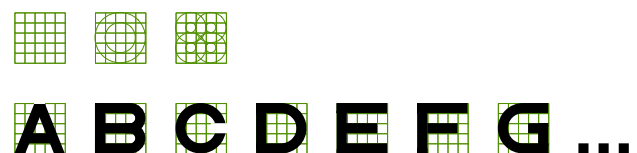


Figure 1. Design language of the Sloan font. The Sloan font is based on a  $5 \times 5$  grid. The thickness of the lines equals the thickness of the white spaces and the thickness of the gap in the letter “C.” The height and width of the optotypes is five times the thickness of the line. In addition to the  $5 \times 5$  grid, there are two sizes of inscribed circles that are used to compose letters with curves.





of the font and pseudofont glyphs. On average, the BACS2 glyphs are less complex than their New Courier counterparts for 21 of 26 cases. So, when one would make an experimental contrast between words and pseudofonts by replacing each Courier New letter with its BACS2 counterpart, the contrast would be matched for number of strokes, junctions, terminators, and symmetry, but not likely on complexity. There is a subset of BACS2 glyphs that closely match their New Courier counterparts (P, O, D, and A, and to a lesser extent I, J, L, and H). PseudoSloan glyphs, in addition to being less complex overall, are less variable, as a set, than are BACS2 glyphs (compare orange with green).

All the files can be downloaded from <https://osf.io/qhj2b/>. The set represents a wider range of complexity and ink area values, and its SVG format supports vector-graphics display techniques. These glyphs could be used to develop alternative matching principles, say matching the BACS2 feature list within certain limits of complexity and ink area matches to the Sloan letters. The full set of glyphs we provide is by no means exhaustive and could be extended to suit the needs and constraints of experiments using artificial orthographies.

*Keywords: text, letters, reading, acuity, false font, pseudo font*

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