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An all-inclusive design space of typographic style in OpenType 1.8 Font Variations

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Keywords

OpenType1.8
Font Variations
Universal font
Typeface Design

Abstract

As OpenType 1.8 Font Variations paves its way as the technological standard in digital typography, the full extent of its capabilities is yet to be realised. By embedding the data required to create specific characteristics or historical styles within its framework there exists a potential to reduce conventional font libraries into a *universal typeface*, able to recall specific typefaces as required by a user. This results in a single file that is accessible across digital environments, able to finesse the typeface so as to satisfy any style requirements.

This dissertation views the way in which typography in the Latin alphabet has originated and how production technologies have influenced typefaces up to the digital formats that we are accustomed to. The manner in which we write has influenced type design for characters to remain legible and is considerably important to early digital parametric fonts and must be respected to build comprehensible typefaces of any given style.

A succinct compilation of 24 exemplary typefaces were selected to reflect historical periods are investigated and compared within Vox classifications (3 typefaces per style) and across the gross data to generate outlines of specific style instances that are interpolable in OpenType Font Variations. The outlines test possibilities of design space arrangements and how component parts and axes can be designed for optimal control, consistency, and rapid generation.

Based on previous ideologies of a universal typeface by means of reduction, and instead redefining it as one of an all-inclusive nature makes use of these technological advancements to create a design space that mimics historical representations of type. The resulting typeface bears 3 axes that relate to the strokes of a writing implement: one of contrast, one of stress and one for serifs; able to be expanded to include greater control of more type design features.

Definitions

Anatomy	*The visual elements that create letterforms.*
Aperture	*The size of the opening to the counter space in rounded letters such as (a) (c) (e).*
Ascender	*The vertical strokes in minuscules which extend above the x-height.*
Bézier Curves	*Control polygon to define a spline accurately by using points on and off the curve.*
Bracket	*A curved or wedge-shaped connection between stem and serif.*
Calligraphic	*The act or appearance of lettering created by hand.*
Cap Height	*The height from the baseline to the top of capital letters.*
Capitalis Monumentalis	*Roman square capitals.*
Character	*A single unit of language such as a letter or punctuation mark.*
Classification	*A system used to divide typefaces into separate categories.*
Contrast	*The difference between the thick and thin parts of a letterforms' stroke.*
Counterpoint	*The pair of points that trace the contours of a stroke.*
Counterpunch	*A tool created to strike a counter of a letterform into an uncut punch.*
Curve Tension	*The level of curvature in a spline described by the distance of off-point nodes in a control polygon.*
Decorative	*A typeface which has unique letter shapes that achieve distinct or dramatic results.*
Delineator	*Pantograph machine invented by Linn Boyd Benton (1885)*
Delta	*The instructions of a TrueType font which shift the control points to a new outline shape.*
Descender	*Any portion of a minuscule letter which extends below the baseline.*
Design Space	*A design space is the range of possibilities of interpolation in a variable font.*
Display	*Type intended for production at large sizes.*
Ductus	*The number, order, direction, scale and speed of strokes as they are written.*
Electroplate	*A metal coating created on a solid template produced by electric conduction through a solution with the dissolved metal.*
Extrapolation	*Estimating an unknown value based on an existing sequence or trend.*
Family	*A set of fonts which have a common design.*
Facsimiles	*A reproduction of an item with historical value that is as true to the original source as possible.*
Font	*A typeface implemented in software.*
	The technology used to reproduce or set a typeface.
Generative Font	*Fonts which redraw or randomise their letterforms during the typesetting process.*
Glyph	*The specific shape or design of a character.*
Glyph Substitution	*The process of replacing a glyph with a another without Unicode.*
Ink Spread	*An increase of stroke thickness as a result of saturation of ink into paper.*
Ink Squash	*An increase of stroke thickness from ink displacement from the pressure of letterpress printing.*
Interpolation	*A method of generating an intermediate instance between two or more values.*
Kerning	*The spacing between individual letters and characters.*
Leading	*The space between adjacent lines of text.*
Legibility	*How well glyphs can be correctly identified as a character or word.*
Letter	*A character which represents a speech sound and part of an alphabet.*
Letterform	*The strokes which make the shape of a character.*
Majuscule	*The capital, uppercase, or large letters of an alphabet.*
Matrix	*The mould used to cast a character.*
Matrix Case	*Type casting equipment for Monotype which housed all the characters of a typeface.*
Mean-line	*The height of the lowercase letters, disregarding ascenders.*
Minuscule	*Lowercase, small letters of an alphabet.*
Multiple Masters	*Adobe font technology containing two or more typeface style outlines that enable a user to interpolate between.*
Optical Size	*The variant of a typeface created for use at a specific size.*
Orthography	*A set of conventions for writing languages*

Outline	*A format which makes use of fillable geometric outlines of characters.*
Overshoot	*The part of a rounded character which extends above and below the dimensions of a square character of the same design.*
Parametric Font	*Programmatically designed fonts.*
Photocomposition	*The exposing of print designs from which printing plates are made.*
PostScript	*Adobe developed font files encoded in outline specifications.*
Primitive	*A piece of a letterform.*
Print	*To produce by a means of reproduction process.*
Punchcutter	*A person creating steel punches, which are then used to create matrices for type moulding.*
Raster	*Digital rendering stored and represented as units or run lengths.*
Revival	*A typeface reinterpreted for contemporary use based on one created in a previous technology.*
Scribe (n.)	*A person who made copies of manuscripts before the invention of printing*
Scribe (v.)	*To act as a scribe/to write down.*
Script	*Hand lettering based using a brush or calligraphy pen.*
Serif	*A smaller stroke regularly attached to the end of a larger stroke.*
Stress	*The angle of stroke contrast in relationship to the vertical axis.*
Stroke	*Shapes defined by sets of contour edges hand drawn by the designer or engraved in metal.*
Type	*The style or appearance of text.*
Type Design	*The art and process of designing typefaces.*
Typeface	*The complete set of letter designs perceived as one specific style of visualisation of characters.*
Upright Roman	*Latin script with vertical stems and interrupted strokes.*
Variable Font	*A single font which contains information which allows it to act as many.*
Vector	*Digital rendering by way of mathematical calculation.*
X-height	*The height of the lowercase letters, disregarding ascenders.*

Acronyms

ATypI	*Association Typographique Internationale*
GPOS	*Glyph Positioning Table*
GVAR	*Glyph variation table*
IK	*Ikarus filetype*
OTF	*OpenType*
TTF	*TrueType*
UFO	*Unified Font Object*
URW/URW++	*Unternehmensberatung Rubow Weber*

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1. Introduction

Creating and reproducing typography constantly evolves, synchronised with technological advancements. The current digital standard for typography is OpenType Fonts developed by large technology corporations; it is open-source and functions across all desktop publishing and network environments. OpenType1.8 Font Variations was released in 2016 and behaves in such a way that end users can interact with a typeface design space to render instances as desired, which may not have been inherently planned by the type designer.

Conventional design spaces are crafted for hierarchical differentiations of the same typeface (such as by width or weight), however, the possibility exists to allow a user to adjust a typeface style or different typefaces entirely using the same process by broadening the design space of a variable font to include those instances.

1.1. Objectives

By providing a user with the ability to create a desired typeface by way of a single variable font, then deciding a typeface may revert to the variable font by default or before finessing a rendered instance for intended use. The repercussions would be a shift in storage of digital type and potentially a *universal typeface* customisable for application in any situation. The success of such a typeface is dependent on the size and accessibility of its design space. The primary objective is the inclusion of any and all typefaces which exist, therefore effectively storing them in a single file and thus the universally applicable typeface.

1.2. Research Questions

Can OpenType 1.8 Font Variations be a means to create a universal typeface that stores and accesses all existing typefaces by a user?

Does reducing the scope to historically significant styles continue to achieve a universal typeface?

How can axes and masters be used to frame a design space that results in a style-fluid typeface that can be intuitively controlled?

1.3. Methodologies

Bibliographic research identifies relevant information that concerns the origins of printed type and its evolution into the current digital format is conducted to appreciate the intentions of typeface designers and the effects of tools on the final appearance of typefaces over time including current digital formats. A literature review expands the understanding and detail of certain topics such as type design and classification systems, the observation of how letters are designed, the crossover of digital software and typography, the ideologies of universal typefaces, and exemplary typefaces and their background. A critical analysis of literature delves into the creation of digital type and component based fabrication systems. The study of these sources provide the theoretical background and understanding required to create meaningful typeface instances in responsive technologies.

Having failed to identify any existing all-inclusive typeface in an OpenType Font Variations format, three separate studies are undertaken to analyse a variety of typefaces in order to create outlines which are possible technologically and to create and assess design spaces of a style fluid variable font. First a mixed non interventional study of 24 typefaces which vary in style identifies patterns and idiosyncrasies on an individual level and across style classifications. The values and descriptions of the results provide a basis for the overall appearance of classifications, and a range of measurements across the entire sample. Secondly a qualitative interventional study draws new outlines of control characters in various typographic styles using the visual and measured data gathered to establish the technical compatibility in the OpenType format against multiple outlines. A final study makes use of the gathered data and outlines to assess how they can be arranged in a design space so significant axes are recognised that provide the greatest flexibility. The methods of drawing and accessing styles via axes in a design space were applied to an entire alphabet developed with the oversight of the supervisors and by consultation of typeface production specialists.

1.4. Dissertation Structure

This paper is divided into nine sections, the first half (sections 2-5) being a review of type design and how it has evolved in both aesthetics and production to the current digital standard, OpenType1.8 Font Variations. The second section of this paper portrays how type design has been influenced by the written hand and print production technologies that have reproduced it, demonstrating a constant bond between these two anomalies. The appearance of typefaces has been dependent on this evolution and often bear the marks of their fabrication. The third section views the assembly of letterforms, how different type is recognised, and how it is defined within the industry in order to differentiate between different styles of type. The definition of these components relies on patterns that exist across typefaces, how they have developed over time, and how the alphabet can be reduced into a series of smaller components. The fourth section examines previous attempts to create responsive type design within digital environments and how technological advancements may contribute in future. The fifth section outlines the emergence of OpenType Font Variations, the systems' architecture and experiments performed using the technology.

The sixth section analyses a controlled selection of typefaces that vary in classification against common benchmarks in order to assess similarities and potential inclusion into a single variable font variations file.

The seventh section draws relationships between typefaces, but more importantly how the data can be practically implemented to an OpenType Font Variations architecture. Previously gathered data is used to create and position outlines and axes to create design spaces that would result in a universal typeface, or otherwise be expanded to entertain the possibility.

The eighth section evaluates previous ideologies of a universal typeface and expands both its definition and demonstrates a possible design space based on Noordzij's stroke theory to achieve a universal typeface whilst retaining the possibility of expanding the breadth of the design space and number of axes in accordance with the findings.

The final section proposes important foundations of a design space that satisfy a universal typeface, and suggests the means to increase the versatility of the typeface so it may cover a wider volume of type design in a single file.

2. Shaping Letters

Typography is the practice of communicating written language in an effective and appealing manner (Bringhurst, 1997). Its most rudimentary factor – *type design* – concerns the appearance of letters (also known as characters) and when all characters of an alphabet (or several) are united the result is a *typeface*. The Latin alphabet, ubiquitous in everyday use, constantly evolves and has not arrived in its current state by chance, but instead through the influence of language, society and technology. Although future iterations of type design styles cannot be predicted, there are certain conventions which make typography legible, providing boundaries which connect all typefaces. The theories of Gerrit Noordzij provide an understanding of how the movement of the hand paired with a writing utensil dictates the appearance of letters since any typeface can be replicated by hand (if not by writing, then by drawing). Early publications provide instructions to reproduce letters accurately at scale, heavily influenced by the renaissance in their efforts to restore Roman culture that have shaped the current appearance of the alphabet In *Upright Roman* form.

The progression of printing technology changes the landscape of how type appears and how it is designed, often limited by their own devices. While scribes of the renaissance have arguably had the largest impact on the appearance of the modern alphabet, the technology engineered for r*apid duplication* of literature or *printing*, has influenced the shapes of letters. Printing has distanced the appearance of letters from scribing, yet adhere to the principles of scribing by necessity. The following section reviews how the Latin alphabet has been formed, the influences of hand-scribing and print production on type design, and the advancement technology of printed type up to digital formats. While type design in digital format is manufactured differently with fewer constraints to past production methods, it takes on historic forms both by choice and by necessity.

The changes in scribing styles and the quests for perfect letterforms have demonstrated how robust the Upright Roman letterforms are, how the writing utensil and its application effects those same letterforms, and how *ideal* type design is not a scientific or mathematical endeavour. Since the overall letterforms are common regardless of scribing styles and the utensils used, there exist features which unify all typefaces, particularly when isolating a single script such as Upright Roman.

2.1. The Written Word

Typefaces are the crafted symbols of written language and vary in design serving the task of dispelling information. This goal can be achieved by any form of printing mechanism or by hand, the latter of which is responsible for the way in which letterforms appear altogether. The combination of hand movement and tool used offers significant change in the appearance of writing and has directly impacted typefaces as they evolved with printing technologies.

A heartline is "described by the midpoint of the advancing counterpoint" (counterpoints being the boundary points of a stroke –"the pair of points that trace the contours of the stroke" (Noordzij, 2009, p. 29)).

Teacher and researcher Gerrit Noordzij published *The Stroke, Theory of Writing* in 1985 where he conceptualises typography based on tools and hand motions (Noordzij, 2009). By applying upward and downward strokes that follow a *heartline*, a letter can be formed. The *heartline* is dictated by the motion of the human hand and can be referred to as the *skeleton* of a letterform. The appearance of a stroke is dependent on the brush or nib shape, the pressure or angle of the utensil, and any rotation applied by the hand; differing stroke styles and hand movements then control typographic style. If a heartline does not follow the *instructions* of a character in the Latin alphabet, the pens applied to it will not reverse this matter and the character will remain illegible.

With excessive speed, a running stroke can "annihilate itself" resulting in an "undulating line" (Noordzij, 2009, p. 39).

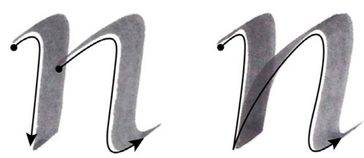

Figure 1. Interrupted strokes (left), running strokes (right), found in (Noordzij, 2009, p. 40).

An initial division in letterform design based on the heartline is described by Noordzij as *running* and *interrupted* strokes *(Figure 1)*, and can distinguish differing scripts. A running stroke *returns* in the same direction of the initial stroke instead of *breaking* and beginning a new stroke for interrupted letterforms. Interrupted construction is easier to maintain control and precision; running script is predominantly a habit of scribing and cursive. *Italics* is a demonstration of a sub-division of Roman script with running characters in contrast to a *sloped Roman (Figure 2)* which Stanley Morison preferred, describing italics "incompatible with the calm regularity of Roman" (Tracy, 1986, p. 62).

This demonstrates how the direction of strokes of a heartline dictates a significant proportion of letterform design to the extent of differentiating scripts. The application of the stroke to an established heartline will provide the remaining appearance of a letterform; or, according to Noordzij, any appearance at all since visualising a heartline requires a stroke itself.

Stanley Morison was a typographic adviser to Monotype between 1923-1967 and designer of Times New Roman (1931).

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Figure 2. Upright Roman (top), Sloped Roman (centre), Italics (bottom), by author.

> *"The stroke is the fundamental artefact. Nothing goes further back than the shape of a single stroke. We cannot postpone a shape by drawing outlines first, because any drawing (outlines included) begins with a shape. Outlines are the bounds of shapes. If there is not yet a shape, there is no outline either" (Noordzij, 2009, p. 10).*

The outlines of a stroke are dictated by the writing implement: the nib of a pen (whether flat, pointed or flexible), a brush, a chisel, or any other geometric shape therein. The method of applying a nib to a characters' heartline dictates the difference between the thinnest and thickest parts of a stroke – its contrast.

Noordzij declares that his theories of creating contrasts are clearly evident in history, with a prelude into the formulation of *western* (Latin) writing in Blackletter, which he calls the *middle ages* and considers it a precursor to the comprehensive written word. He describes at length the peculiarities of scribing with a broad nib pen in varying styles of Blackletter and the tendency of scribes perceiving beauty as repetition and uniformity that ultimately destroyed the *word image*. Great improvements in legibility were a result of a nib that had a *swelling counterpoint (Figure 3)* by expansion and rotation. Noordzij notes how the shift in tools from a broad nib to a pointed flexible nib (and even ballpoint) are the tools responsible for these historic changes, noting that "there are combinations of material and equipment that do not accommodate the making of upstrokes." (Noordzij, 2009, p. 39). This declaration distinguishes letters which are *written*, and those which can only be *drawn*.

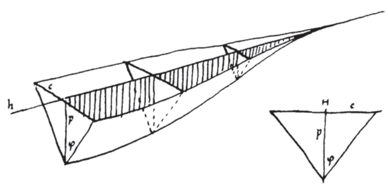


Figure 3. The spacial model of expansion of a writing utensil, found in (Noordzij, 2009, p. 31).

According to Noordzij's theory, a typeface with no contrast exists when a *flexible* nib (round nib or brush) is used with no other influences and creates a stroke of uniform width throughout the entire stroke. The resemblance of such a uniform stroke-width is familiar to many Sans-Serif typefaces that have very low

"Translation: antiquity and the middle ages
Rotation: mannerism
Expansion: romanticism"
(Noordzij, 2009, pp. 26-27).

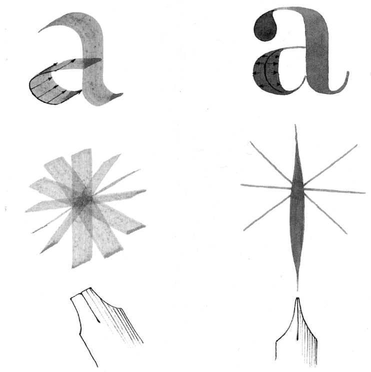


Figure 4. Contrast by Translation (left) and Expansion (right) (Translation and Expansion, n.d.).

contrasts. By adjusting technology and technique, contrast is created in three ways: *expansion, and translation (Figure 4) and rotation*. Should the impression of the tool expand with pressure and therefore leave a wider stroke, contrast can be dictated by the amount of force used while traversing the heartline. Noordzij called this is *contrast through expansion*; the tools which leave such impressions being brushes and flexible nib pens. By changing the nib behaviour to a fixed size, and from a single point to a *broad nib* (or a shape) at a fixed angle, contrast is created by the angle of the nib in relation to the direction it travels along the heartline. When these two angles are parallel, the impression is at its finest as the majority of the nib travels along the stroke it has recently created. The opposite applies for a broad nib travelling perpendicular to its angle of incline. This angle dictates the *stress* of a typeface and often reflects the angle of the calligraphic hand. Noordzij describes this as *contrast by translation*; however, should the angle of the broad nib change while travelling along a path, so too will its stroke, creating *contrast by rotation*. To achieve a constant stroke-width along a curve with a broad nib, the angle of the nib must be perpendicular to the tangent of the curve at all times.

By these methods, the stroke-width and therefore the contrast can be controlled by the nib type, shape, size, and angle at which it travels along a set path. It is this theory which entertains the possibility of a heartline to evolve into any number of different appearances when drawn in an almost programmatic manner.

2.2. Writing and Drawing Letters

The earliest available means to reproduce texts was by way of manual scribing or writing; when the process is mechanised the tools used and resulting reproduction of text are inevitably different. In the process of writing, the nib of the implement dictates the resulting shape; in movable type, the shape of the block dictates its impression; digitally, mathematical equations calculate shaded areas — each abstraction of writing has the possibility to change its design, yet often reverts back to writing by necessity for legibility.

> *"The history of typography reflects a continual tension between the hand and the machine, the organic and geometric, the human body and the abstract system. These tensions which marked the birth of printed letters over five hundred years ago, continue to energize typography today" (Lupton, 2004, p. 13).*

When moveable type was first introduced into Europe in 1440, Blackletter typefaces *(Figure 5)* became *"the original standard for printing, mainly because they mimicked the handwriting style of the time"* (Chapman, 2020). Gutenberg's point of reference for his initial typefaces was Blackletter, familiar in the biblical scriptures he set out to reproduce. He so diligently pursued scribed aesthetics that *"he reproduced its erratic texture by creating variations of each letter as well as numerous ligatures"* (Lupton, 2004, p. 13). Scribes of the Middle Ages employed interrupted strokes, the familiarity of the stroke shapes and the "*perfect rhythm*" which they looked to achieved resulted in heavy, dense and repetitive characteristics, reducing its legibility, which ultimately reduced its usage and popularity as both printed type and scribing styles evolved (Noordzij, 2009, p. 53).

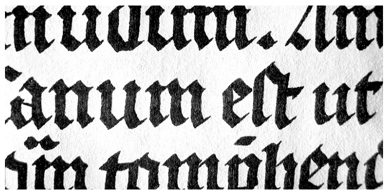


Figure 5. The monotonous strokes of Blackletter found in (Pizarro, 2020, p.28).

Nicolas Jenson was a French goldsmith turned printer and type designer who trained in Mainz, Germany (possibly apprenticed by Gutenberg) and migrated to Venice, Italy where he established a printing firm (Lupton, 2004). For his first book there, *Eusebius* (1470), he designed an upright Roman based on Roman *Capitalis Monumentalis* (majuscules) and *Letter Antiqua* (minuscules). Letter antiqua was in actuality based on Carolingian script which Humanists of the Renaissance had falsely assumed to be of Roman origin and adapted to be closer in appearance to Roman capitals by adding serifs and finishing strokes, coining the *Humanist* type design style (Boardley, 2016) (Stock-Allen, 2011). Although printed typography based on humanist script already existed (by Sweynheym and Pannartz in 1465 and the de Spiro brothers in 1469), the typefaces cut by Nicolas Jenson are hailed as being the first true upright Roman designs. The letterforms created by Jenson can be assumed in static in their design – *"this form of letter might be thought of as the last evolutionary stage of the Carolingian minuscule"* (Hoefler, 1997). The longevity of his designs is not only due to the quality of production and attractiveness, Chapman (2020) describes them as "*the first to be created based on typographic principles rather than manuscript models."*

Figure 6. Shape geometry compared to Roman Square Capitals, created by author, Typeface: Trajan Pro (1989).

Early printed typography reflected the scripts available and were cut accordingly as seen with Blackletter and Eusebius; however, the design of the letters and schematic diagrams for assembly already existed as a means of engraving text accurately at different scales (Shpilko, 2012). The renaissance saw many publications concerning letter design, particularly with respect to the Roman Capitalis Monumentalis. Geofroy Tory suggested that the use of circle, square and triangle shapes by the Romans *(Figure 6)* was a means to and result of achieving perfectionism and are still references significant for designing letters, overshoots, and kerning between similarly shaped characters (Shpilko, 2012). Other calligraphers such as Felice Feliciano, Fra Giocondo da Verona, Luca Pacioli, Geoffroy Tory, Gianfrancesco Cresci, Giovanbattista Palatino, amongst others, attempted to create perfect replicas or ideal letterforms often using geometric shapes or proportions of the human body *(Figure 7)* (Luc Devroye, 2023). While this doesn't constitute mathematical proportions, historical type design often follow these relations to the human body or as ϕ (the golden ratio) for assessing stem widths to matrix heights.

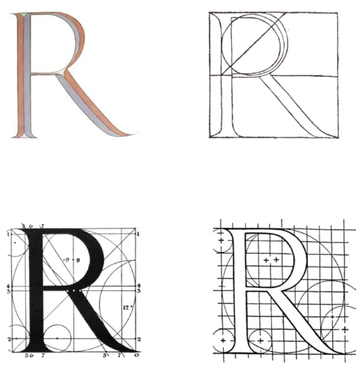


Figure 7. Square Capital (R) by Felice Feliciano (top left), Damianus Moyllus (top right), Giovambaptista Verini (bottom left), Geoffroy Tory (bottom right) from (Shpilko, 2012, p.29).

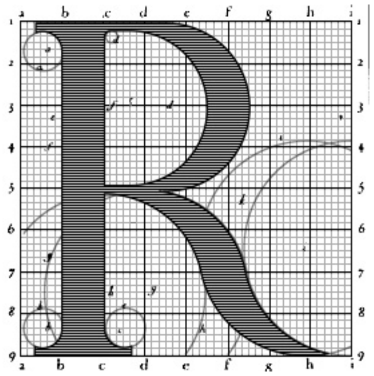


Figure 8. Romain du Roi drawings of (R) and (S). From (Yukechev, 2020).

The majuscule (R) "curved leg reveals the calligraphic origin," where "any geometrically constructed (R) would have a straight leg at the junction with the head and only its tail would be curved" (Shpilko, 2012, pp. 8, 28).

An early typeface lesser associated with scribing in favour of a rational, calculated design is *Romain du Roi (Figure 8)*. Commissioned by the French monarch King Louis XIV and designed by an Academy of Sciences in 1693 (Lupton, 2004), (Shaw, 2017); Romain du Roi (1693) strived to be the *"perfect form that symbolised the royalty of the King"* (Yildirim, 2012, p. 6). To achieve this, the Academy of Sciences concluded in a report that a more rational approach was be taken by designing a *"Roman alphabet constructed on a mathematical basis… each traditional Roman letter being constructed using a rule and compass on a grid of 2,304 squares"* (Bazerman, 2009, p. 61). However, it's seen that in the transition from the initial designs by Jacques Jaugeon, to copper engravings by Louis Simmoneu in 1695, to the punches cut by Philippe Grandjean in 1702, that the actual letterforms do not conform to the scientific endeavour (Shpilko, 2012), (Shaw, 2017). Thus *"Romain du Roi violated the fundamental principle of the geometrical construction"* (Shpilko, 2012, pp. 8, 28).

Romain du Roi (1693) is found at a historical junction where more distance is made between calligraphy and printing (Luc Devroye, 2023). Typefaces designed before this period are often known as *Old Style.* Romain du Roi (1693) becomes the first of the *Transitional* styles which were followed by *Modern* styles with higher contrasts and narrower serifs made possible by improved print technologies (Shaw, 2017). Type design becomes increasingly calculated and distanced from manual scribing, however, "*the final arbiter of the design was the eye, not mathematics"* (Shpilko, 2012, p. 8), enforcing the constant tension between mechanised and written letters.

2.3. Printing Letters

Type design originates with the written word shaped by scribes and calligraphers whom pursued elegance in their work in their duty to transcribe information with the skill to recreate differing styles or scripts depending on the nature of the document. These roles have been diminished by the advent of printing which has required type to be designed around the peculiarities and limitations of printing technologies, which has influenced the style of typefaces.

The limited character set of the Latin alphabet provided German goldsmith and craftsman Johannes Gutenberg the opportunity to mechanise the printing process of scriptures around 1440 (printing existed in the orient prior to this, but the complexity of the language meant it was common that entire blocks of texts were carved or cast). Gutenberg cast individual letters in metal via a reusable moulding system, leaving a legacy of process and terminology still used and proclaiming him as the creator of movable type (Cullen, 2012), (Baines & Haslam, 2005).

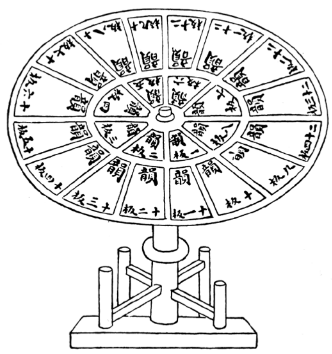


Figure 9. Movable type as it existed in the orient found in (Meggs, 1998).

The process of casting metal type begins with the cutting of a letter in reverse into hardened steel by first creating counter-punches for counters that could be applied to several letters of the same style. Once a punch was completed, its impression would be transferred to a copper plate onto which a mould is set with appropriate width and point size to create a matrix for casting in metal. Casting a different point size would require restarting the process with a punchcutter preparing new punches for the intended size who would *"enhance the appearance at specific point sizes"* via *"subtle adjustments in letterform contrast, proportion and weight"* (Cullen, 2012, p. 74). The punchcutter was responsible for the subtle adjustments of typefaces to maintain appearance at differing sizes and materials *(Figure 10)*.

Renown type designer Gerard Unger describes counter-punches as 'interchangeable part' (Unger, 2018, p. 97-98).

Figure 10. Optical sizes of Century Optical sizes of Century, found in (Lilley, 2021).

Ink squash and *ink spread* are a result of pigment expanding on paper further than the letters through the pressure applied by the printing press, and of absorption by the paper respectively. The compensation for ink spread can be best seen in Matthew Carter's Bell Centennial (1978) *(Figure 11)* designed for optimal legibility at small sizes. The condensed appearance and small sizes are key economic decisions and to realise its appearance the typeface is designed with large ink-traps to compensate for rapid printing on low-grade paper quality susceptible to ink-spread (Smits, 2014).

Punchcutters were often responsible for adjusting a typeface for a desired style or for intended use; an experienced punchcutter could influence the style, improve legibility, and respond to the behaviour of inks and paper in print production. Technological improvements in paper, ink and metallurgy finessed the design of type, allowing punchcutters to significantly increase contrast in letterforms, eventually leading to the delicate hairline serifs of Modernist styles.

William Berkson suggests that ink-spread "operated in letter press as a kind of automatic "optical correction" for smaller sizes. It is in effect a uniform addition to the thickness of all the stokes. But the strokes are not uniform in thickness. Adding a few thousandths of an inch to a fine stoke may double or triple its thickness, and while making only a slight percentage difference in a thick stem" (Berkson, 2010).

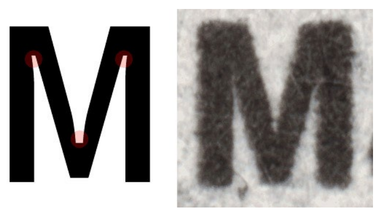


Figure 11. Ink traps of Bell Centennial size 6pt (left) and result after print production (right) found in (Smith, 2014).

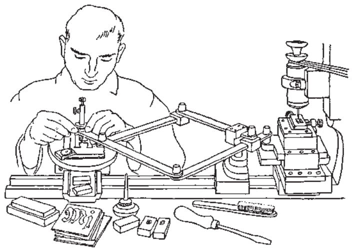


Figure 12. Matrix Engraving by Pantograph found in (Tracy, 1986, p. 36).

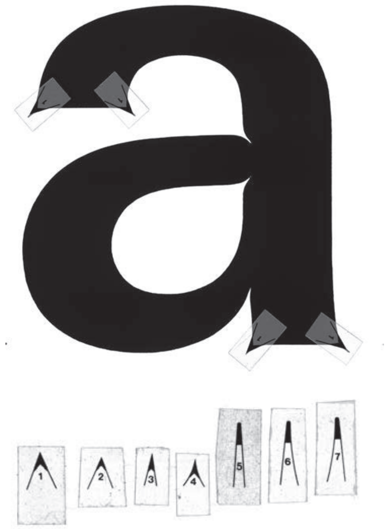


Figure 13. (a) of Universe (1957) as designed for filmsetting (top), and adjustments required for accurate reproduction (bottom), found in (Osterer, 2012, p.104).

The trade of the punchcutter (and influence on type design therein) begins to diminish in the nineteenth century with technological advancements such as *electroplating* and the *pantograph (Figure 12)*. Electroplating uses electrical charges to coat a surface with a metal dissolved in a solution creating exact copies of surface reliefs and requires a matrix of the same size for duplication (defined as electrotyping when duplicating typography) (Tracy, 1986, p. 37). It is the pantograph which further minimises the need for punchcutters. Pantographs work on geometrical principle in order to make copies, able to do so at different scales. Linn Boyd Benton who creates the *delineator* pantograph in 1885 that is not only able to make accurate scaled duplicates, but also able distort the outlines for scales such as *width* and *slope* (Fleishman, 2017). The delineator allowed for faster production of matrices at various sizes and with greater accuracy, but lacks the optical compensations which punchcutters were responsible for (Tracy, 1986, p. 86).

The pantograph fit snugly with the invention of mechanical typesetting/hot metal casting and was most beneficial for Linotype machines, which *"chewed through matrixes and ate up punches because of its operation"* (Fleishman, 2017). Hot-metal typesetting rapidly casts single-use type by letter (Monotype) or by 'line of type' (Linotype). Linotype stored matrices with duplicate characters in magazines, and fell prey to a problem whereby two styles (such as weight or italic) share the same matrix and same space therein. Monotype had a *keybar* which was paired to letters in a single matrix case (Tracy, 1986); without a keybar the output would be entirely monospaced. Altering the point size or typeface within a hot-metal typesetting machine involves the substitution of the magazine or matrix case and thus were limited to single sized typeface styles during operation. The advancement of printing in lithograph, offset and eventually digital printing is responsible for making metal type entirely obsolete, where the impression of letters is transferred to media by other means.

Nested between the improvement of offset printing and digital technology, *photocomposition* introduces a new method to create and process typography for printing. A typeface is created in negative on a single glass or film disc, light is then passed through a chosen letter followed by a magnification glass that adjusts to the desired size being exposed on film for print. The matrix size becomes abstract, allowing letters overlap one another if required. As with ink-spread for letterpress, the letterforms of phototype need to be adjusted for accurate reproduction on film as they are *"subject to some distortions, inherent in light-exposure on film"* (McLean, 1997, p. 84) *(Figure 13)*.

2.4. Digital Letters and Screen Displays

The digital age has alleviated a need to store type in a physical sense entirely, instead storing the data needed to recreate shapes which is achieved in one of two ways, by *raster* or by *vector (Figure 14)*. Rasterised typography stores units or run lengths to enclose geometrical areas, essentially *counting* the blocks in a matrix to create a shape. Lowering the resolution of a raster matrix generates a less accurate representation of the letter with a proportional reduction in storage space. In theory, the best practice of using a rasterised typeface would be to generate new instances at the required reproduction size. *Hinting* is used to improve the accuracy of typefaces when rendered on screen displays (particularly at low resolutions); locations on the outline are prioritised to be visible over the regular alignment of outlines to an available pixel grid *(Figure 15)*.

Vector formats are mathematically *calculated* outlines, scalable without loss in quality or change in storage footprint. A flexible spline fixed at extremes could be manipulated into curves by adding intermediate points to create tension in the spline, the *Bézier* curve is a vector line format which follows this spline principle *(Figure 16)*. Bézier curves became the basis of the Adobe PostScript format and continue to be the de facto basis of vector typography (Knoth, 2011), *"mainly because the slope of the curve can be easily controlled by successive pairs of on-curve and off-curve points"* (Hu, 1998, p. 19). When using Bézier splines to design letterforms it is best practice to place points at extremes in gridded format (vertical and horizontal) for rasterising at different resolutions and to aid hinting. (Hu, 1998).

Designing type in digital vector format avoids many faults and limitations present in previous printing techniques. Type no longer needs to be created in reverse at any specific size and the improvement of offset and digital printing avoids ink-squash and light refractions. Moreover, the adoption of Bézier curve vector format over different industries extends printing of type into new dimensions such as etching, CNC carving and 3D printing. However, just as typefaces return to written construction principles, digital type need also merit principles and procedures of old tendencies such as ink-traps, or, more importantly, optical sizing.

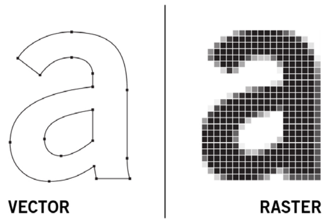


Figure 14. (a) in Vector (left) and raster (right) found in (Ratermanis, 2017).

Figure 15. Unhinted (left) vs hinted (right) found in (Karow, 2009, p.26).

Bézier curves were created by Paul Casteljau in 1959 on the work of Pierre Bézier who used the calculations for automotive design. A Bézier curve is defined by its end points (on-curve points) and two control points (off-curve points) which create the control polygon that encloses the parametric curve (Hu, 1998) (Knoth, 2011).

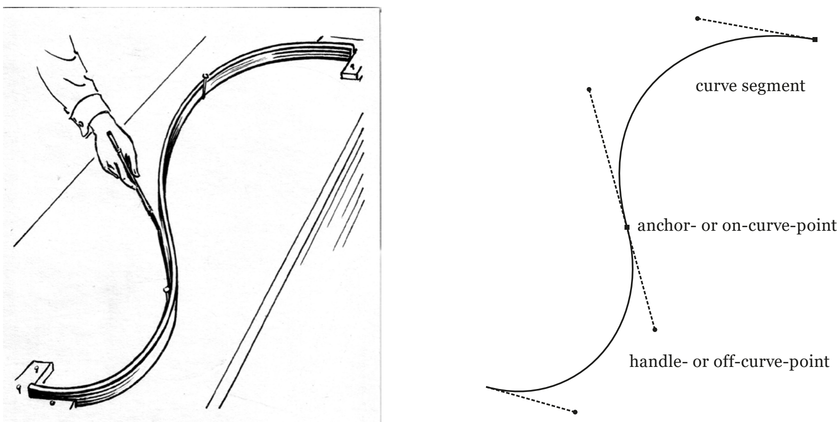


Figure 16. Spline System (left) and Bézier Control Polygon (right) found in (Knoth, 2011, p.8).

3. The Familiarity of Type

Since the manner in which typography is written or printed may dictate its appearance, various techniques and technologies ultimately results in aesthetic differences; however, every method is unified by the letterforms themselves to remain legible. Gerrit Noordzij theorised principles in which all typography can be created, yet he notes boundaries: *"the freedom of lettering is limited by convention. Not that drawing unconventional shapes should be difficult or forbidden, but shapes that do not conform to convention are just not writing"* (Noordzij, The Stroke Theory of Writing, 2005, p. 9).

In the same way that block printing dissected entire bodies of text into letters of an alphabet, letterforms themselves can be segmented into their component parts. Viewing an alphabet in this way can serve three purposes: definition of the components necessary to create a legible typeface, the relation and recurrence of components which may have multiple repetitions through the alphabet, and features which define the overall style of a typeface. The component parts of an alphabet and across different typefaces are well defined and can be used to illustrate a specific character; furthermore, the characteristics of these parts can define the style of a typeface when compared to others. While the anatomy of letterforms is relatively stable, the manner in which typefaces are compared to one another remains more haphazard. The following section investigates the current Latin alphabet in its upright Roman state, methods in which it may be constructed through component parts, followed by the systems used to define and segregate styles.

3.1. Anatomy of Type

In order to classify typefaces or produce legible characters there needs to be a general understanding of how letterforms are constructed, their components, and the rules which govern recognisable characters. By defining the anatomy of letterforms which remain constant the identifying features which differentiate typefaces and styles can be analysed and compared.

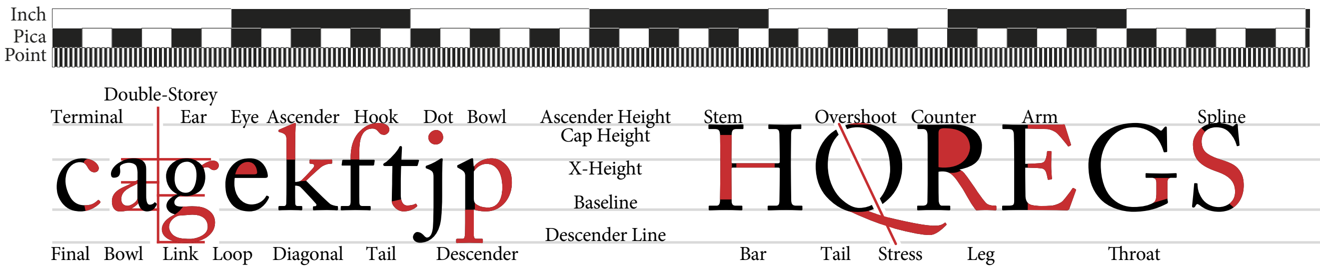


Figure 17. Anatomy of Type, Adapted from Design Elements and Fundamentals (Cullen, 2012, p. 34) and (Cheng, 2006, p. 12).

Authors often employ different terminology for the same individual strokes and counters in a character. The dissection and definition of parts of type found within letterforms such as serif styles, the vertical metrics, contrasts, etc. have been published by Cullen (2012), Bringhurst (1997), Pizarro (2020), and Baines & Haslam (2005) to name a few. These authors contextualise the typographic styles in historical timelines and what comes to define them. In *Designing Type,* Cheng (2006) compares various typefaces at length by individual letters; she demonstrates what differentiates them and how the strokes of characters are designed. This is an invaluable resource for understanding well-designed type, approached in such detail that historical contexts are lost.

"Type design is to a degree modular design" (Unger, 2018, p. 98).

By simply defining type anatomy, the recurrence of terms reveals how many components are shared or closely related within the same alphabet; clear examples being stems, bars, shoulders, bowls and serifs. *"Repeating components of letters such as counters is common in digital type design"* and dates back as early as 1580 by Hendrik van den Keere who created counters with *"a counterpunch as an identical and interchangeable part,"* which distinguished type designer Gerard Unger defines as *'modules'* (Unger, 2018, pp. 97-98). Designing a typeface by components can increase speed and uniformity, which researchers Philippe Coueignoux (1973), Debra Anne Adams (1986), and João Cunha et al. (2016) make use of for rapid type design systems.

As part of his doctorate research at Massachusetts Institute of Technology, Philippe Coueignoux researched typography as components to create a *Simulated Character Design* programme (1975) in which relatively few components need be adjusted in order to create bitmap characters at great speed. He dissected type into a modular system using *primitives (Figure 18)* that *"generally correspond to character pieces"* (Eutamene, Belhadef, & Kholladi, 2013, p. 53). He divides an alphabet into 13 parts for repetition with no single character accumulating more than four individual primitives at any time, adjusting the style of the primitives by separate rules; the shape is filled once the primitives are arranged into a chosen letter.

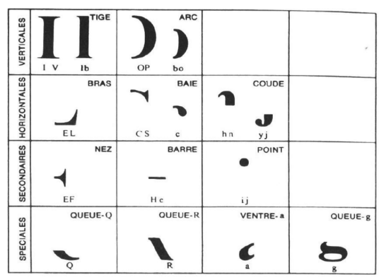


Figure 18. Philipe Coueignoux Classification of Primitives (Eutamene, Belhadef, & Kholladi, 2013, p. 53), Produced from (Coueignoux, 1973, p. 44).

Debra Anne Adams analysed the structure of letterforms for her research *A Dialogue of Forms: Letters and Digital Font Design* (1978) as a means to construct digital typefaces rapidly. Along with similarly derived *part primitives* of letters, she relates the shapes of characters to one another as a result of the strokes they are comprised of resulting in a *control characters tree*. She recognises that parts *"may seem visually consistent, [but] repeating part instances often differ in their physical geometry due to the visual interactions within and among letterforms. Therefore, each repeating part instance can be inherently non-uniform in character"* (Adams, 1986, p. 25). João Cunha, Pedro Martins, Tiago Martins and Penousal

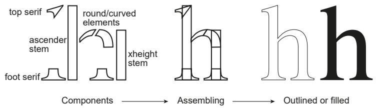


Figure 19. Parametrisation of digital type by shape model, found in (Hu, 1998, p.9).

Machado created a tool in 2016 using component parts in order to quickly design visually consistent typefaces by part sharing. They arrived at same conclusion declaring that their tool is a preface to the manual adjustment required by a designer to *"correct any imperfection and make slight adjustments (e.g. optical compensations)"* (Cunha, Martins, Martins, Bicker, & Machado, 2016, p. 7).

Analysing anatomical components can provide insights to attributed style and how similar character sets are created when historical influences are correctly understood as uniformity of these components changes across styles and with each face. As an oversimplified example the serifs in a Sans-Serif typeface are all equal: lacking in height, depth, bracketing and roundness; in contrast to Humanist typefaces with wide, shallow, asymmetrical serifs and modulated strokes.

3.2. Indexing Typefaces and Indexing Type

To acknowledge that a typeface is different to another, there need be a way of describing both. Given that a typeface comprises of an entire alphabet, descriptions of characteristics shared between its letters can explain its overall style without analysing individual letters. Whenever a collection of typefaces share the same characteristics, it can be assumed they can be categorized together. A basic example is typefaces without serifs share the same description as each other: Sans-Serif. With more common descriptors, typefaces will become more similar.

Typeface classifications are the systems in which typefaces are visually described and organised so as to be able to navigate to a specific typeface or range of typefaces within a library; they would otherwise be arranged alphabetically, chronologically, by size, or any other largely arbitrary system. The 19th century was prolific with regards to newly designed typefaces and printers of the time increasingly required a means in which to index and archive type (Cullen, 2012). When early classification models were created there *"was a growing interest in the study of historical typefaces"* (Baines & Haslam, 2005, p. 50), which is often reflected in the terminology and seemingly chronological arrangements of early classification systems. Grouping typefaces must be done visually as *"letterforms are not only objects of science. They also belong to the realm of art, and they participate in its history"* and thus have multiple means of description which may not be relatable to one another (Bringhurst, 1997, p. 121). Baines & Haslam (2005) portray visual groupings as beneficial to *"produces smaller groupings,"* compiling typefaces more similarly (Baines & Haslam, 2005, p. 50).

Type classifications is a contentious issue regularly revised with models sharing a common goal of categorising or indexing typefaces into a coherent system. The work of Childers, Griscti, & Leben (2013) reviews the names of style classes and subclasses of 25 classification systems to see how often names are shared in an attempt to standardise terminology. The challenge is that when classifying a single typeface "one style *can have two, even three names, all meaning essentially the same thing. Typographers who create [classification] systems often have a difficult time deciding which name to choose. Sometimes they choose both"* (Childers, Griscti, & Leben, 2013, p. 1).

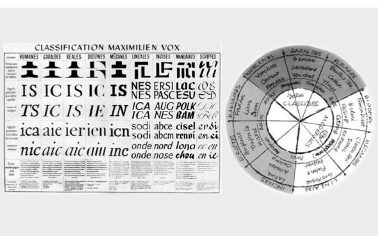


Figure 20. The 'Vox Model' classification system created by Maximilien Vox in 1953 found in (Lallaizon, 2021).

Maximilien Vox (1894-1974) was a French designer with roles such as Artistic Director of the Ministry of Information and artistic advisor to the Deberny & Piegnot type foundry.

The turn of the twentieth century had already established a number of classification systems, notably that by Francis Thibaudeau in 1921 for archiving the Piegnot Foundry's materials. He devised a separation of four classifications (*Roman, Didot, Egyptian,* and *Antique*), before later including *Script* and *Display* for decorative typefaces used in advertising (decorative typefaces are notoriously difficult to classify). This was a precursor of the *Vox* model *(Figure 20)* created in 1954 by Maximilien Vox, who increased the number of categories based on historical timeline with new terminology and sans-serif classes based on visual appearance (Alessio, 2013), (Sesma, 2014). The Vox model has become *"the best-known classification ... survived possibly thanks to its adaption and adoption by the Association Typographique Internationale (ATypI) in 1962 and the British Standard in 196."* (Pizarro, 2019). The classification model has been adjusted by ATypI in 1967 to include *lineal* class subcategories, and British Standards reduced the number of sub-classifications, and removed Blackletter entirely (Childers, Griscti, & Leben, 2013). Pizarro (2019) notes how even these modifications to the Vox model; *"said classification does not include contemporary designs"* (Pizarro, 2019).

Ellen Lupton's classification system *(Figure 21)* published in *Thinking with Type* (2004) has seven categories exemplified with demonstrative typefaces that are based on a chronological timeframe, clearly separating serif and sans-serif typefaces. She declares that for decorative typefaces *"there is no better way to handle the oft-fought-over topical typefaces than to ignore them completely. As seen with other type classification systems, these often get lumped into an "other" category or they become part of a multiplayer system with too many terms"* (Childers, Griscti, & Leben, 2013, p. 9). Ellen Lupton's classification system is structured similarly to that of Robert Bringhurst published a classification system in *The Elements of Typographic Style* (1997) *(Figure 22)*, clearly defining styles which are largely based on a chronological timeframe, and ignores decorative styles. A striking difference between Lupton's classification is a lack of distinguishment between serifs and sans-serifs, in theory being able to attach the feature as a suffix to one of his classification categories.

In contrast to other classification systems, Catherine Dixon attempts to be more inclusive; *"Dixon's system simply says that if a typeface exists, then it should be able to be described"* (Baines & Haslam, 2005, p. 52). She devised a classification system where typefaces are described in three sections: *sources, formal attributes,* and *patterns* (Dixon, 2008) *(Figure 23)*. Dixon claims that *"the new description framework operates on the assumption that the formal character of every typeface can be described in terms of its specific configuration of these two components: sources and formal attributes"*. It is one of the more complex classification systems when considering the number of sub-classifications, and as a result potentially the most inclusive. What becomes evident when considering the sources of a serif typeface is the inevitable link to chronological descriptions.

Departing entirely from a chrono-linear categorisation method, PANOSE system was developed by Benjamin Bauermeister and published in *A Manual of Comparative Typography* (1988) and subsequently purchased by Hewlett Packard to support Infinifont, a parametric type design software (De Laurentis, 1993).

It assigns a numerical definition unique to the typeface based on ten characteristics such as family type, class, weight, contrast, and serif variant amongst others. In effect, PANOSE holds a design space in which all typefaces can be described and their similarities measured by Pythagorean theorem (De Laurentis, 1993). It is also able to describe distortable typefaces in a fashion which is almost measurable via numerical matrix, and as a result demonstrates its value for parametric design software.

Although there are challenges and inconsistencies describing and categorising typefaces, they are always relatable to one another regardless of the classification system used (which could exclude a typeface altogether). When more volume or more detailed descriptors are used, typefaces can be grouped more similarly. The level of detail of any observation is only as significant as the frequency of its repetition across typefaces, and by viewing typefaces at varying intervals of detail bring the relationships of typefaces closer. Although sophisticated classification systems exist with ample definitions, there is a relative familiarity to users of chronologically based classification systems such as the Vox model due to exposure and education of those classification systems.

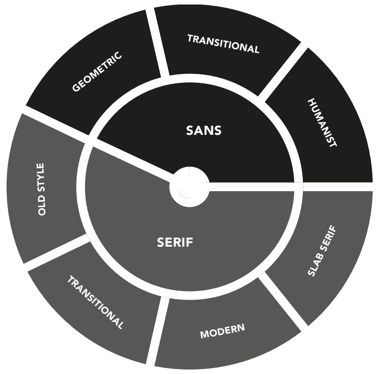


Figure 21. Ellen Lupton classifications, Thinking with Type (2004); from Childers, Griscti & Leben (2013).

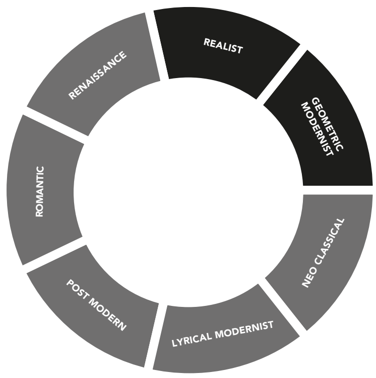


Figure 22. Robert Bringhurst classifications, The Elements of Typographic Style (1997); from Childers, Griscti & Leben (2013).

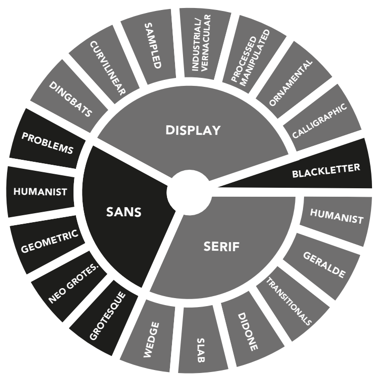


Figure 23. Catherine Dixon classifications, Eye Magazine (1995); from Childers, Griscti & Leben (2013).

4. Adaptive Typography in Digital

The digital age has brought new ways of storing and creating typefaces. Letterforms no longer need be created in reverse and are unconstrained from physical barriers such as matrix widths or volume for storage. The interactivity of typefaces themselves are unprecedented and can not only be generated instantaneously by end users, but it has become possible to generate typefaces entirely using mathematically based programs, and even without the need for any designer input. Parametric fonts commence the technical opportunity to create new typefaces that can be user-defined or responsive. With the exception of generative fonts, these open-ended and interactive type design systems revert back to existing typefaces. A prime example is the intent of METAFONT to match letterpress printing, whose most successful typeface, Computer Modern (1985), reverts to existing typefaces as inspiration. However, it is the methods in which typefaces are adjusted which provide the limits and capabilities of the resulting typeface.

4.1. Parametric

Parametric fonts are typefaces created by computer programming and have existed since the 1970s. *"The term parametric originates in mathematics, where it describes equations that use one or more independent parameters to express coordinates defining a curved geometric object or surface"* (Riechers, 2018). These parameters can be compared to the theories of Gerrit Noordzij, where the inputs dictate either the heartlines which build a letter or the strokes which provide its style and contrast – "*Parameters, such as x-height, stroke-width and letter-width are numeric parameters that can be set and then a new font generated based on those parameters"* (Brath, 2017).

Mathematician Donald Knuth created the first parametric type design system METAFONT in 1977 in attempts to match the quality of digital printing to metal type. The technology is *"a programming language reliant upon geometric equations to construct its letterforms"* and follows Noordzij's principles – the glyphs are described by pen strokes along heartlines, both of which can be altered by a user through its parameters (Glasson, 2018). Knuth summarises the program succinctly: *"three P's of METAFONT -drawing with pens and parameters via programs"*. Knuth tries to justify how *"the programs are able to record the 'intelligence' that lies behind a design"*, when user-input changes default values (Knuth, 1985, pp. 39, 38).

"1 It is based on a language for drawing shapes with simulated pens that have thicknesses.

2 The METAFONT language also encourages the construction of designs with explicit parameters, so that a large family of shapes can be described, rather than a single shape.

3 In order to support characteristics 1 and 2, METAFONT descriptions of letterforms are given as programs" (Knuth, 1985, pp. 36-37).

METAFONT was not only the first parametric font software, but also incredibly sophisticated and is still used as the engine for contemporary parametric font programs such as *Metapolator* (2018) and *Metaflop* (2015). It is entirely capable of describing typefaces of varying heartlines and typographic styles, however the success of these programs appears to be limited, with Knuth confessing that *"it is not easy to describe the essence of shapes to a machine"* (Knuth, 1985, p. 38), and he simply could not define (S) programmatically, instead describing the outlines (as in conventional type design practice). Glasson (2018) attributes this as its downfall, becoming overly complex for users and *"the exact opposite of user-centric design,"* that *"the model of describing letters as pen strokes simply does not always allow a designer to implement what the font requires: the model fails to capture reality"* (Glasson, 2018).

Metapolator is a web browser extension which uses METAFONT as a programming engine, however, instead of creating entirely new typefaces, the outlines of an existing typeface are converted into stroke-based parametrised font systems with a centreline and stroke-width. *"The core principle of Metapolator: Typefaces are systems of shapes, and by naming the parts we can control the system"* (Metapolator, n.d.). A duplicate of the original is adjusted by parameter values before interpolating or extrapolating between the pair which requires "*a qualified professional using his or her expertise to define the range of the typeface's appearance"* (Riechers, 2018).

Created by Yannick Mathey in 2011 and retired in 2020, Prototyp.io was designed to be more user friendly. It boasted an intuitive user interface and *"the starting point is a ready-made font with manipulation of 30ish parameters, such as x-height, width, thickness, slant, serif width, serif height, bracket curve and so on"* (Brath, 2017). Prototypo uses components to build letters with strokes and serifs separately, allowing a user is able to quickly and flexibly design a typeface with the possibility to adjust individual glyphs and individual nodes when required.

Developed by Clyde McQueen III and Raymond Beausoleil for the ElseWare Corporation in 1991, infinifont creates typefaces based on PANOSE codes in order to reduce disk space (Knoth, 2011) (Beausoleil & McQueen, 1993). The technology has 3 components: 1 - the *Terafont*, which becomes transformed with 2 - *PANOSE* values, executed by 3 - the *FontEngine*. The Terafont acts as a dictionary of type behaviour needed to compile a typeface in two stages; *Terafont global* programs applied across the entire typeface, and *Terafont functions* which aids the assembly of the individual glyph components. The Font engine runs the two stages; first using PANOSE values to calculate glyph outlines, which can then also be adjusted with global and local overrides for further customisation, particularly important for precisely matching existing typefaces.

Ikarus is a type production software developed by Peter Karow for Unternehmensberatung Rubow Weber (URW) in 1972 with the primary objective of digitising and storage. Using a lens cursor *(Figure 24)*, a user would plot curves and tangential points along the outlines of a character displayed on paper after which precise and manual adjustments would be made (Blokland, 2019). IKARUS became bolstered with parametric programs – outlines, inlines, shadows, reliefs, rounded corners, italicising (slanting) and even *"the automatic generation of optical sizes"*, which could be computer generated without user-inputs. This behaviour is comparable to parametric software, running programs and requiring *feature definitions*. *"Considering that the technology worked on the basis of single master fonts, the results are of remarkable quality, still unmatched today under the aspect of optical scaling"* (Ahrens & Mugikura, 2008, p. 22).

Peter Karow never found a method to increase the weight of a typeface using the single set of outlines describing any results *as "substandard looking"* (Karow, 2013, p. 18); the design of weights was not calculable due to conflicting requirements such as *"a stem weight increase of 7% if the type size is reduced by a factor of ½"* while *"the necessary weight adjustment is reversed in semibold and bold designs, where the small sizes are supposed to be lighter than display sizes"* (Ahrens & Mugikura, 2008, p. 32). The solution proposed by Gerhard Rubow was to use two masters and interpolate between them, which "immediately worked well, but needed twice the amount of work for input" (Karow, 2013, p. 18). This early demonstration of interpolation between differing outlines remains common practice, yet Karow also experimented interpolating between differing styles Antiqua and Grotesk *(Figure 25)*, concluding that *"nobody likes it"* (Karow, 2009).

Blokland (2019) sources Karow's archives to show the recreation of the Noordzij Cube using the IKARUS digitizer, and a letter of apology from Noordzij to Karow – "now that I have made my cube myself, it's become clear to me how much work I gave you with my request to digitize the cube quickly"; further expressing Noordzij's difficulties in how "the interpolation routine of IKARUS does not seem to be entirely waterproof" (Blokland, 2019).

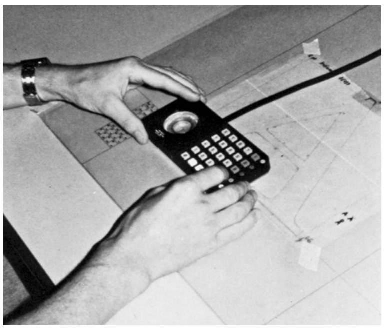


Figure 24. Tracing outlines of (A) with a lens cursor for input into IKARUS, found in (Karow, 2013, cover).

Figure 25. Interpolation from Antiqua to Grotesk styles by Peter Karow, found in (Karow, 2013, p.23).

4.2. Generative Fonts

Generative fonts can create or manipulate typefaces without designer input: *"Generative fonts redraw and can even randomize their letterforms during the typesetting process, adding elements of uncertainty, chaos and surprise to the traditionally precise, specific discipline of type design"* (Reichers, 2016). FF Beowolf (1990) *(Figure 26)*, the first generative font created by Just van Rossum and Erik van Blokland introduced a *randomness* parameter to PostScript font outlines that created unique outlines (without repetition) during print production. Generative fonts need not be adjusted randomly and can be applied to various digital frameworks; for instance, a generative font can calculate parameters to locate a typeface instance from within an interactive design space as in the logo and branding for Goertek, created by Lindsø & Michaëlis (2018). Goertek uses sound frequencies to adjust a variable font in real time using decibel or frequency measurements as axes values (Lindsø & Michaëlis, 2018).

Figure 26. Letter (E) of Beowolf increasing in randomisation, (van Blockland & van Rossum, 1990).

4.3. Artificial Intelligence

The dawn of the artificial intelligence revolution brings an opportunity to create typefaces without any designer input by machine-learning. Using a Deep Convolutional Generative Adversarial Network (GAN) with a large typographic dataset of 200,000 different fonts Process Studio (2019) created AIFont (2019) *(Figure 27)*, an animation where each individual frame was a new typeface generated by artificial intelligence – "*an endless stream of new typefaces which oscillates between different font weights and styles*" (Process Studio, 2019).

AIFont creates typefaces from a large dataset and Hayashi, Kohtaro, & Uchida (2019) note the unpredictability of results created in this manner for their own study of improving AI generation system *Deep-Fonts*, outlining a theoretical framework to narrow the output by including limitations *(Figure 28)*. By simultaneously running a d*iscriminator* whose data is based on existing styles (called a *hot vector*), the output of the *Generator* can be trained between a *minmax* (minimum and maximum) value. The practical implications of this would be the generation of typefaces closer in aesthetic and relation depending on the level of discrimination, for instance, the minmax values as the bounds of a specific historic style or classification.

Figure 27. Letters generated by artificial intelligence for the Uncanny Values animation found at (Process Studio, 2019).

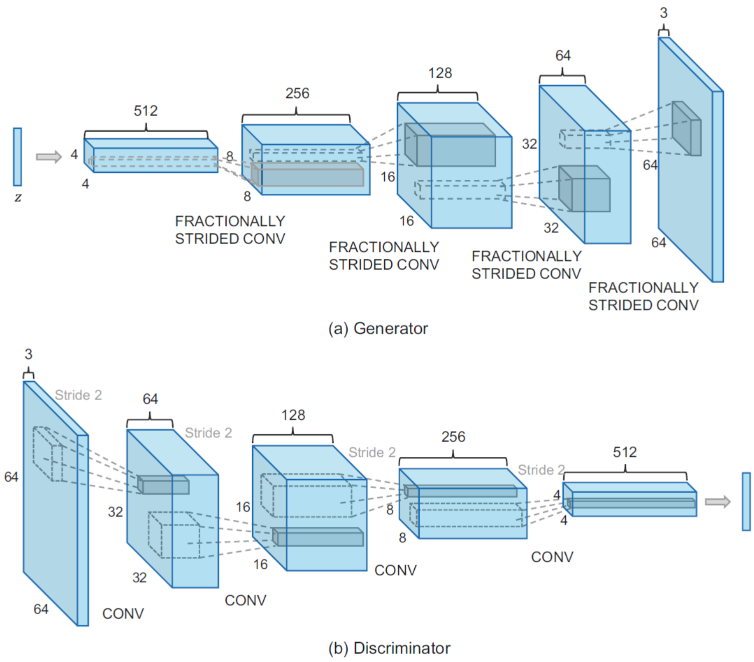


Figure 28. Structures of the generator and the discriminator. found in (Hayashi, Kohtaro, & Uchida, 2019, p. 14).

5. OpenType – Expanding Digital Typography

OpenType is the current standard for digital typography and is a result of turbulent relations of technology giants competing over print superiority of typography. The technology is open source with an architecture that is comfortably similar to previous digital font technologies with added flexibility and industry compatibility. In recent releases, it supports the inclusion of multiple outlines of the same character instances within the same file that even basic applications can access and serve to users.

The return and improvement of deltas opens the possibility for users to customise typefaces without type design knowledge or facilities. Creating masters which support interpolation requires the fulfilment of some basic principles that are already common considerations of contemporary type designers. By understanding OpenType1.8 Font Variations and its architecture, the design space of a font can be calculated to include existing typefaces or historical interludes, alleviating a user's need for extensive libraries and freedom to customise, or even create their own typeface.

5.1. Opening Type

In the early expansion of desktop publishing, the Adobe Corporation created a software standard for digital printing in 1983, *PostScript* (Knoth, 2011). In safeguarding their *Type 1* font format (a lucrative font licensing system in demand for high quality printing of typography) a series of business alliances known as the *Font Wars* erupted. Through tumultuous relations between large tech companies (Adobe, Microsoft and Apple), competing technologies were developed (Mendelson, 2000). The rivalry subsided with the desktop publishing industry benefiting from powerful tools which were compatible between operating systems and printing technologies (Shimada, 2006). The resulting OpenType format created in 1997 is now an industry standard closely related to its predecessors and is supported by Adobe, Apple and Microsoft (Shimada, 2006). Google has since joined the contributors for the release of *OpenType1.8 Font Variations* in 2016 (Hudson, 2016).

"Monotype ran an experiment by combining 12 input fonts to generate eight weights, across three widths, across both the Italic and Roman styles. Storing 48 individual fonts in a single variable font file meant a 88% reduction in file size" (Crossland, Kurtuldu, Nieskens, & Steiner, 2018).

The primary interest of Font Variations for the tech firms is a reduction in filesize and load times (Berning, 2017), (Brown, 2016). Where regular compression methods of multiple font files were based on a container format (i.e. zip file), *"a variable font redefines how information is stored in the font file"* (Berning, 2017). This saving in footprint is highly appealing where bandwidth has a cost and load times effect user experience (Crossland, Kurtuldu, Nieskens, & Steiner, 2018). Although particular attention is being paid to OpenType Font Variations on the internet, the benefits differ for print-design where the storage size of a typeface is negligible. Ted Brown, the head of typography at Adobe predicts that *"[what] variable fonts will do for a print designer will give you infinite in-betweens"* and solve issues such as *"faux bolds"* (Brown, 2016). Font Variations offers a return of craft and the ability for type designers to amplify a typeface's design, able to include incremental variety such as weight, width, or optical sizing. For users this amounts to interactivity and the freedom to explore a design space, it "*equips its users with access to fine, micro grading options that will be available dynamically and above all, automatically instructed by separate software or context that facilitates their behaviour"* (Mietkiewicz, 2017).

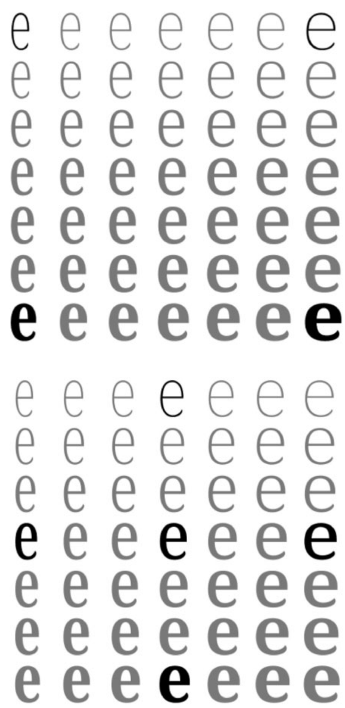


Figure 29. Adobe Multiple Masters Framework (top) and Apple TrueTypeGX framework (bottom), by Tom Rickner (2016), found in (Fernandes, S. 2019, p117).

OpenType 1.8 Font Variations works by storing the information needed to create more than one arrangement of the nodes which instruct the Bézier curves into different shapes. The model closely resembles its immediate predecessors created by Adobe (*Multiple Masters*) and Apple (*TrueType GX*) *(Figure 29).* Adobe Multiple Masters (MM) technology was released in 1991 for use with the PostScript1 font format. It requires separate *master outlines* placed at extremes that encapsulate the design space and a user or designer could then generate *instances* by interpolating a typeface at a specific location within the design space. If the instance did not satisfy a type designers' requirements it would require further manual adjustment of a specific instance (Ahrens & Mugikura, 2008). There were relatively few Multiple Master fonts released, lacking in both widespread programmatic support (including Adobe's own software) and also that *"the users, civilian graphic designers, who were puzzled by how to use it"* (Black, 2017).

TrueType GX was released by Apple in 1991 as a development of QuickDraw GX. The design space is centred on a single set of outlines which are shifted into *deltas,* which behave in the same manner as master outlines (Black, 2017) (Hudson, 2016). A benefit of this model is that it allows the possibility for a user to interact with a design outside of the design space – *"beyond what the designer has explicitly explored and controlled"* (Fernandes, 2019).

5.2. Architecture of Font Variations 1.8

The OpenType Font Variations architecture is largely modelled on Apple TrueType GX systems, which were considered superior to those of Adobe (under the assumption that PostScript cubic Bézier and TrueType quadratic Bézier curves produce the same result) (Hudson, 2016). For simplifying terminology and given the behaviours, it can be assumed that a *master* is a set of font outlines for use with interpolation and extrapolation; thus deltas and master outlines share the same definition.

Master outlines set the boundaries of the design space and control the possible iterations therein by defining the relationship between two masters *(Figure 30)*. A single master does not enclose a design space and only exists as a single instance; Richard Brath explains that without creating the shifts of outlines, then *"that axis will not be available to manipulate"* (Brath, 2017). By including a second master and defining its relationship to others results in an axis of interpolation which a user is then able to control. While the architecture of OpenType1.8 limits the number of axes to 64,000 (Brown, 2016), there is *"a sanity limit for type designers, since each additional axis multiplies the complexity of the design space. Overly-complex variable fonts can also be confusing to end users, who may struggle to understand how to make effective use of the possibilities"* (Hudson, 2016). Under a Multiple Masters framework with masters placed at extremes, the number of masters increases exponentially with to the number of axes (Shimada, 2006).

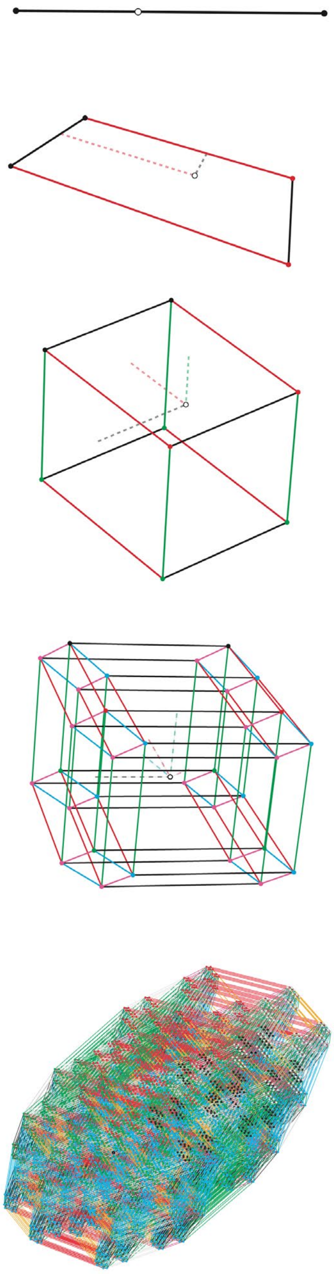


Figure 30. Multi-dimensional figure representing the design space of variable fonts with 1 axis (top), 2 axes, (2nd from top), 3 axes (middle), 5 axes (2nd from bottom), 12 axes (bottom). Created by author using Multidimensional Axis Visualizer by (Kuzmin, A. & de Groot, L. 2018).

To assume full control of the design space in a Multiple Masters framework (master outlines placed at corner extremes):

A single master holds a single instance with no axes,
A single axis binds two masters,
Two axes bind four masters,
Three axes bind eight masters;

Required masters (M) increases exponentially with the number of axes (a) with at a base of 2: $M_a = 2^a$

If all masters (M) are required, all 64,000 axes (a) would have: $M_{64,000} = 8.3 \times 10^{19,265}$

This number can be approximated as *infinitival*.

By mathematically tracking the changes in node location between masters, a user can use axis values to select the location of the nodes between the master outlines. This process is called *interpolation* and occurs in real time allowing a user to render typeface instances which occur between the masters and thus within the design space. It is possible to arrive at instances outside the design space by *extrapolation*, where the mathematical sequence is calculated beyond the master outlines which set the trend. A practical example would be to create the outlines of light and bold typefaces; a regular weight can be interpolated and extra-light and extra-bold weights can be extrapolated *(Figure 31)*. Interpolation is a tool frequently used by type designers and Robert Slimbach explains how *"it is most useful if aiming at a very stylistically consistent family with a uniform progression"* (Ahrens & Mugikura, 2008).

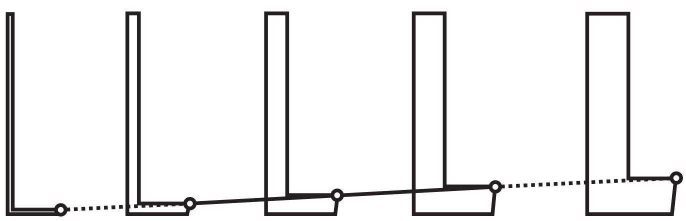


Figure 31. Interpolation (solid line) and extrapolation (dashed line) of the letter (L), by author.

It has been shown how master outlines are related to one another through a bonding axis which figuratively *stores* the interpolation formulae. The mathematical calculation for interpolation requires that any and all points in a letter must have equal points in the corresponding masters for outlines to communicate correctly *(Figure 32)*. This is not limited to the Bézier curves and must exist across all values, *"if glyph shapes are changing across variations design space, then their spacing is also changing, and all data in the Glyph Positioning 'GPOS' table will need to undergo corresponding adjustment"* (Hudson, 2016).

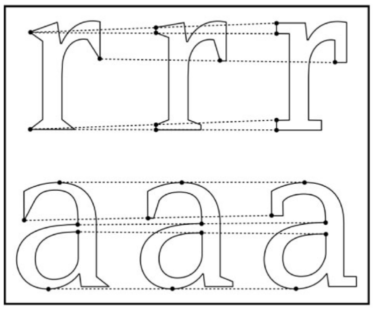


Figure 32. Changes to Serifs and terminals during interpolation, by Adobe (1995), found in (Fernandes, 2019, pg.114).

The practical implications of data storage in OpenType Font Variations are evident if one were to consider the outlines of a Sans-Serif whose stem ends in two nodes at right angles, then to create a Slab-Serif there need be an additional four nodes totalling six control points. Sometimes the structure of a letterform or its heartline can change entirely; This phenomenon can be tackled by creating axes which have a soul purpose of a sudden *"toggle between variations, or a series of discrete changes without intermediary variations"* (Hudson, 2016), defined as a *"glyph substitution capability"* (Crossland, Kurtuldu, Nieskens, & Steiner, 2018).

5.3. Universal Fonts in Variable

Created by Briton Smith in 2020, Universal Sans is an exploration of variable technology viewing *"the possibility of using [axes] creatively to change the character of a typeface, rather than the conventional axes of weight, width, italic or optical size"* (Boddington, 2019). The typeface has 58 masters and six axes: weight, width, x-height, ink-traps, terminals, and proportions. Glyph substitution allows anatomy changes such as single and double storey (a) and (g), bowl style of (a), figures, amongst others, with a programmatically skewed oblique style. The intended use of Universal Sans is to reduce the build time of a new sans-serif typeface and although it aims to provide a unique personality of a typeface it is limited to Geometric, Neo-Grotesk, and Humanist Sans-Serif typefaces.

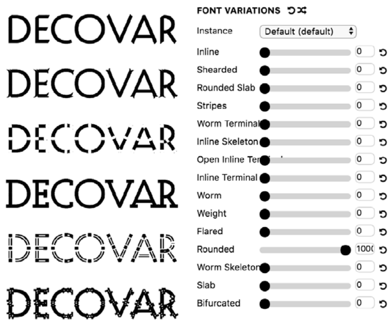


Figure 33. Decovar axes found in (Strizver, 2018).

David Berlow is a pioneer in the capabilities of OpenType Font Variations and has been twice commissioned by Google for proof-of-concepts – AmstelVar (2016) and DecoVar (2017). DecoVar (2017) has abundant control over the appearance of a typeface with a fixed heartline. There are fifteen unconventional axes *(Figure 33)* such as *Worm*, *Stripes*, and *Flared* that influence strokes that appear to be split into two shapes with terminals and do not bridge junctions. In contrast, AmstelVar (2016) has twelve axes *(Figure 34)* which have more usual axes such as weight, width, optical size and grade; the remaining axes adjust the heartline particularly with respect to its metrics: ascenders, descenders and x-height can all be adjusted. In these demonstrations of the flexibility of OpenType Font Variations, DecoVar (2017) is limited to experimentation and decorative in use; and AmstelVar (2016) is an extended typeface family.

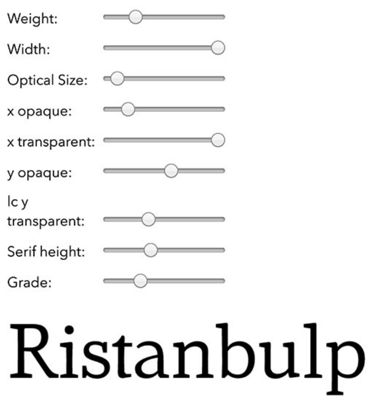


Figure 34. Amstelvar axes found in (Berning, 2017).

The expansion of OpenType1.8 Font Variations presents a considerable amount of flexibility to users and presented as an accessible industry standard. The manner in which a design space is crafted holds the opportunity to adjust a typeface beyond a family and instead into a series of possible styles.

6. Analysing Typefaces

6.1. Research Design

To entertain the possibility of combining multiple typefaces or style classifications within an OpenType Font Variations framework three conditions must be met: the instances in question must exist within the design space; the geometries of all styles must be relatable for interpolation to function; and the axes of interpolation must be able to navigate a design space to generate the desired instances.

An analysis of typefaces is made to visually describe characteristics and compare similarities of a variety of typefaces so the bounds of the design space can be formulated. The bounds of the design space and how instances are placed and accessed will be determined from the typefaces and classification styles from the investigation. This non-interventional mixed quantitative and qualitative study considers a varied, yet carefully chosen range of typefaces and specific letterforms for a comprehensive and uniform synopsis.

To assess the compatibility of differing styles within an OpenType Font Variations environment, an exploratory study yields the outlines of varying styles representative of historical categories. Since all master outlines contain equal and approximate geometries, the outlines may also require nodes that do not contribute to the appearance of letterforms. Should the coexistence of master outlines that vary in styles be relatable, the behaviour or location of each style within the design space is assessed in conjunction with appropriate and relatable axes to predict a smooth transition of nodes. The observations, data, and outlines collected from this analysis of typefaces will be used to speculate and create design spaces that are both technically and objectively compatible.

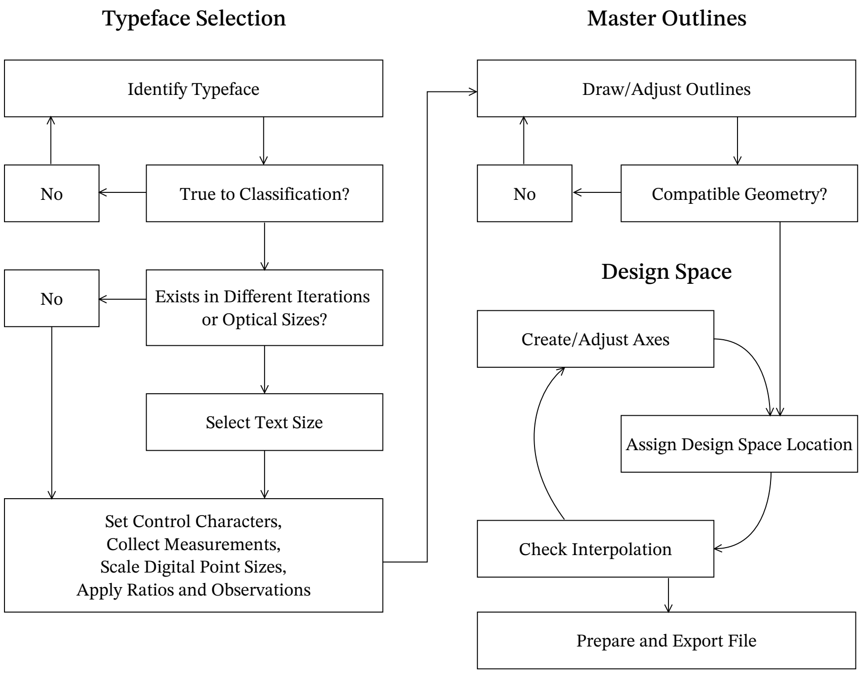


Figure 35. Outline of Research Methodology.

6.2. Methodology

6.2.1. Typefaces

Conducting an exhaustive analysis of *all* existing typefaces manually is an unrealistic endeavour, and instead a concise categorical approach is implemented. Achieving a design space which encompasses historic styles requires the identification of classifications to be used and to populate these with typefaces. To assess the historical movements of typographic styles in upright Roman script, the style groupings are as follows: *Humanist, Old-Style, Transitional, Modern, Slab-Serif, Humanist Sans-Serif, Grotesk, Geometric Sans-Serif.* Each style group will be represented by three typefaces for a comparison within the style, as well as a culmination of all data across the study.

The chosen typefaces (*Annex 1*) must be an accurate representation of the style classifications and will be limited to digital font files which negates any printing errors and inconsistencies. *Revival Type: Digital Typefaces Inspired by the Past* by Paul Shaw (2017) offers a succinct catalogue of digital typefaces with various renditions and their relation to the original typeface. Where multiple digital renditions of the same typeface exist, selecting those with common criteria such as weight and optical size increases the consistency of comparisons.

By displaying typefaces with common benchmarks, their characteristics can be more accurately compared. A preliminary measurement is by digital point size; however, since this does not correspond to the physical sizes at which the typefaces were originally designed, the point size must be calculated for each typeface to match the common benchmarks. To isolate measurements, ratios are made against the digital point size in order to scale outlines to the correct comparative size.

For a common stem width, the required point size is calculated using the following ratio:

$$pt_r = \frac{St}{AvgSt} * em$$

Where pt_r is the required point size desired St stem width for a typeface with existing (and average) stem width AvgSt and correlating resolution of em space and averaged when modulated.

A uniform stem width with a fixed baseline allows comparisons for the height of vertical metrics (mean-lines, ascenders, descenders and cap height) and the overall run length of a controlled character provides insight into character widths and weights. For instance, a pair of typefaces on the same baseline with equal stem widths and run lengths yet varied cap height and mean-line would lead to the assumption of differing letter-widths; or, most likely, a difference in weight of a typeface.

The following calculation provides the digital point size for a uniform cap height (Ch):

$$pt_r = \frac{Ch}{AvgCh} * em$$

Fixing cap height provides a good basis in which to view relationships in character width of majuscules, which is particularly important when investigating similarities to classical Roman proportion as well as overall widths of letterforms.

6.2.2. Letterforms

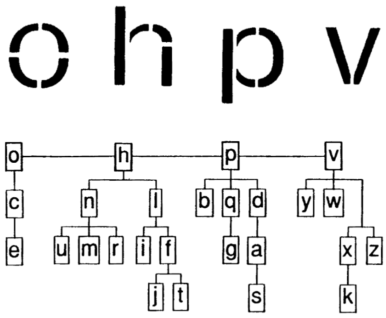


Figure 36. Control characters (top) and letters related to control characters (bottom) by Debra Adams found in (Adams, 1986, p.59, 63).

Focusing on letterforms with the most information reduces the sample size from 52 letters per typeface. Debra Anne Adams calls *control characters (Figure 36)* letters that relate *"depending on their degree of similarity in shape or structure, on the number and kind of decisions that need to be made to define their shape attributes and values"* (Adams, 1986, p. 63). As such, characters with the most primitive parts will be considered for a good understanding of the remaining alphabet.

Lowercase

(a), (c), (e), (f), (g), (h), (j), (k), (p), and (t) will be selected for comparison of minuscules. These letterforms display stems, curved shapes, turns, crossbar, shoulders, whether characters are single or double-storey, and contrast between angular strokes.

Uppercase

(E), (G), (H), (O), (Q), (R), and (S) will be selected for comparison from the majuscules. These will be used to compare stems, stress, contrast, classical-modern proportions, the height of crossbars, terminals, beard and chin, and horizontal serifs.

Serifs and Terminals

To succinctly review serifs, the top and bottom serifs of (l) will be viewed, and the terminal of (c).

6.3. Data Analysis

Several tools have been devised for comparison derived from measurements and presented as ratios such as contrast and proportion. Physical sizes of type are measured (*Annex 2*)for comparison and for creating ratios and normalising characteristics across multiple typefaces (as used in standardising cap heights or stroke widths). These measurements shall be defined *size* and are proportional to digital metrics sizes. Comparative ratios can be displayed visually by way of slope angle, where a diagonal of 45° indicates a 1:1 ratio between measurements; this method of analysis can be defined: *by way of angle*. The stress of a typeface will be observed in (O) by creating a plane tangential to the highest level of contrast (between the minimum stroke-width); the deviation in degrees from vertical in a counter-clockwise direction is measured and defined: *stress.* Other characteristics in a typeface can only be described qualitatively. The constant irregularities of these components are more aptly defined by eye and shall be measured by *observation*.

The characteristics for comparison are as follows:

By Angle

Proportion (E-O): the difference in proportion of (E) and (O).

Contrast: the difference in proportion in the width of (O).

By Size

Ascender height, cap-height, x-height, baseline (fixed), descender line.

Stress

by Stress.

By Observation

Serifs and terminals.

Curve tension/roundness: the variance of (O) from a geometric circle.

Stroke modulation: whether stems are of uniform width.

Optical /aperture size.

7. Findings

7.1. Overview

There are 24 typefaces compiled in the study. A holistic view on the sample set shows overall boundaries and scope; although the overlay of characters does not provide exact definitions for letterform construction, there are clear limits visible in negative space which keep letters legible when viewed with a fixed cap-height. From a fixed point size the variation in character width or disparity in sizes can be noticed by the run-length of the alphabet as well as the ascenders and descenders of characters (particularly clear in (J) when it occurs below the baseline, and in the tail of (Q)).

Better relationships can be understood from the representations of stress, contrast and proportion. When observing stress the maximum angle is 21° from vertical, yet the majority of typefaces have vertical stress (0°) (this is only known due to the sample size). What is evident is that there is no *negative* stress, and while these may exist (including horizontal stress in reverse-contrast typefaces), they lie outside the sample set and it can be concluded that they are usually classified as decorative styles.

The degrees of contrast between an almost entirely monoline 1:1 value, to the single outlying extreme of the Modern Ambroise (2001) of over 1:15 (or 86° slope by way of angle). These contrasts are generally split into two sections: Humanist, Old-Style, Transitional, Modern; and Slab-Serif, Grotesk, Geometric and Humanist Sans-Serif. Monoline typefaces are well represented within the study, and Ambroise (2001) represents extreme contrast as a revival of a display typeface.

Proportion

There is a relatively compact relationship between (E)-(O) proportion, particularly if the some of the outlying typefaces were to be omitted (true Roman proportions, Slab-Serifs, and FF DIN (1995) which has an abnormally condensed (O)). It must be noted that the graph indicates a relatively narrow change in proportion by slope variation, but the implications in design are a substantial reduction in the width of (E) – approaching 50%. The graph indicates a certain amount of repetition in proportion at both extremes of the proportion angle. The inclusion of a proportion axis could then be represented in either a linear progression between extremes, or glyph substitution or for a more controlled outcome.

Line Heights

When constraining the stem width and aligning baselines, there is a large disparity in ascender-height, cap-height, mean-line and descender line regardless of considerations of typefaces of similar weights, sizes, and use. The negative space surrounding the baseline provides a brief insight into minimum clearances and some general trends when considering the descender lines alone. This is less difinitive of values above the baseline which are hard to segregate from differing metrics.

Stress

Over half typefaces have a vertical stress, which therein can be represented as a default starting point 0°. Those typefaces with stress present a moderately even distribution of values, slightly skewed towards the final 21° value.

Contrast

The contrast in stroke has a maximum ratio of 1:1 for typefaces with no variation in stroke-width, and there appears to be three general trends: an even split between those typefaces which have low contrast (approaching 1:1), followed by a high contrast (around 1:2). The third potential trend is extreme contrast, represented here by Modern typeface Ambroise at approximately 1:15. Ambroise is one of the few of the sample which is a display typeface and skews the contrast data as a result.

Serifs and Terminals

When considering terminals, the comparison of the sample set by cap-height shows the variation in stem size and ascenders, causing a misalignment in the serifs and terminals. Although complex, there does exist enough similarity in the bottom left serif of (l) to imply a general trend in serif sizes, and likewise in the upper-serif (l), particularly when at an angle. As with the serifs of (l), there appear to be some averages in the terminal of (c), however, these averages do not represent clear letterforms.

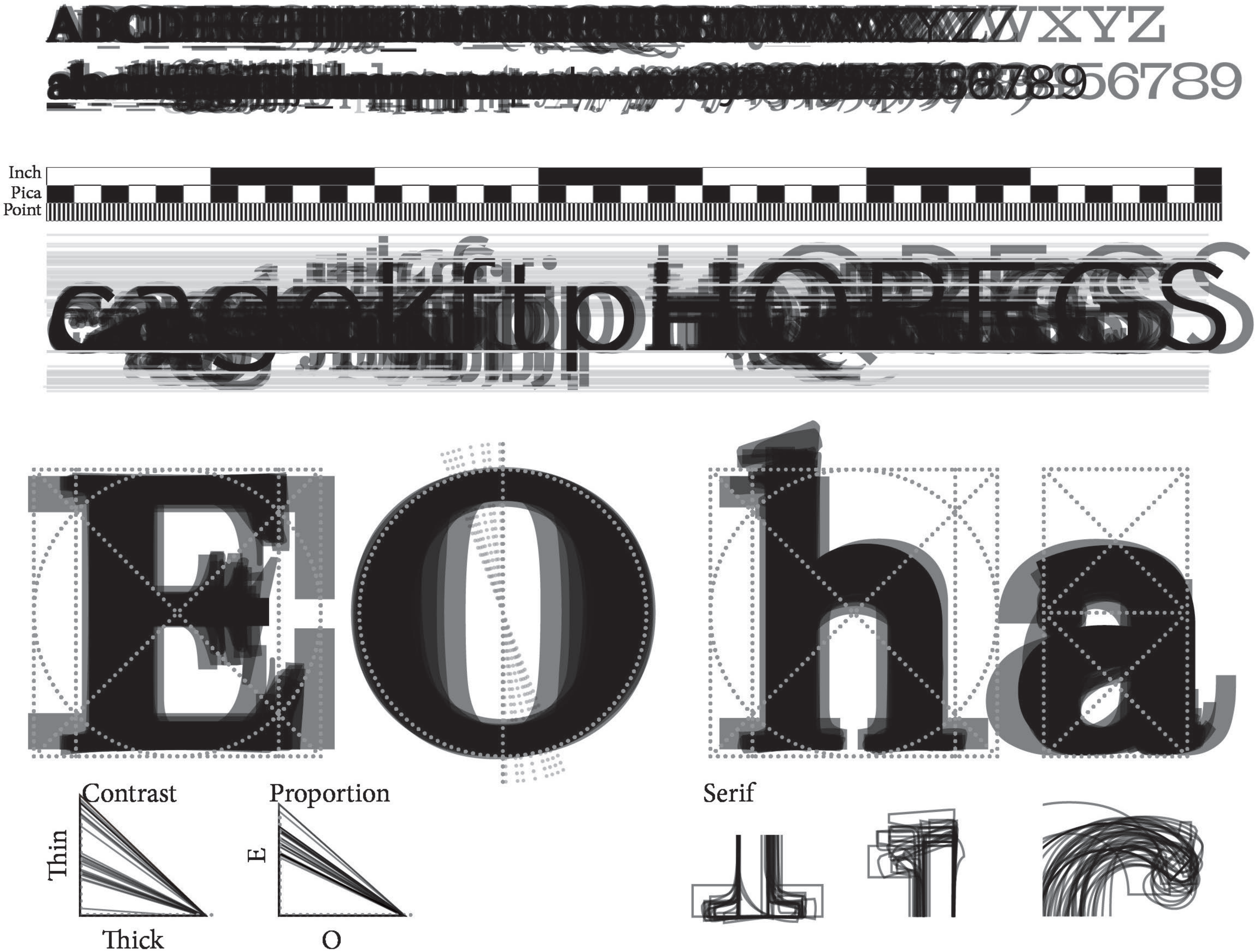
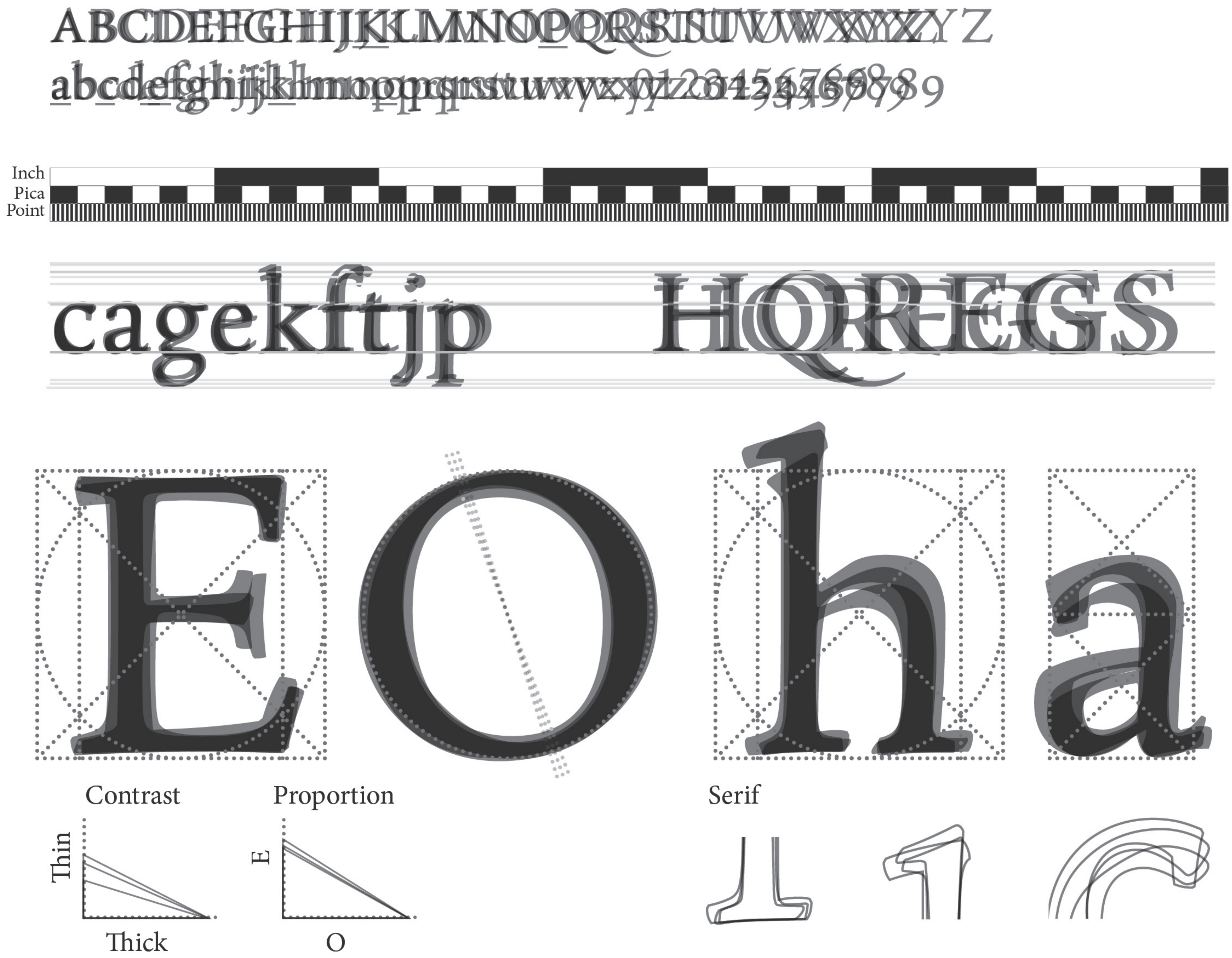

Inch
Pica
Point
Contrast
Thin
Thick
Proportion
E
O
Serif

Figure 38. Overlay of Humanist Typefaces

Adobe Jenson Pro (1996)
Marco (2015)
Neacademia (2012)



7.1.1. Humanist

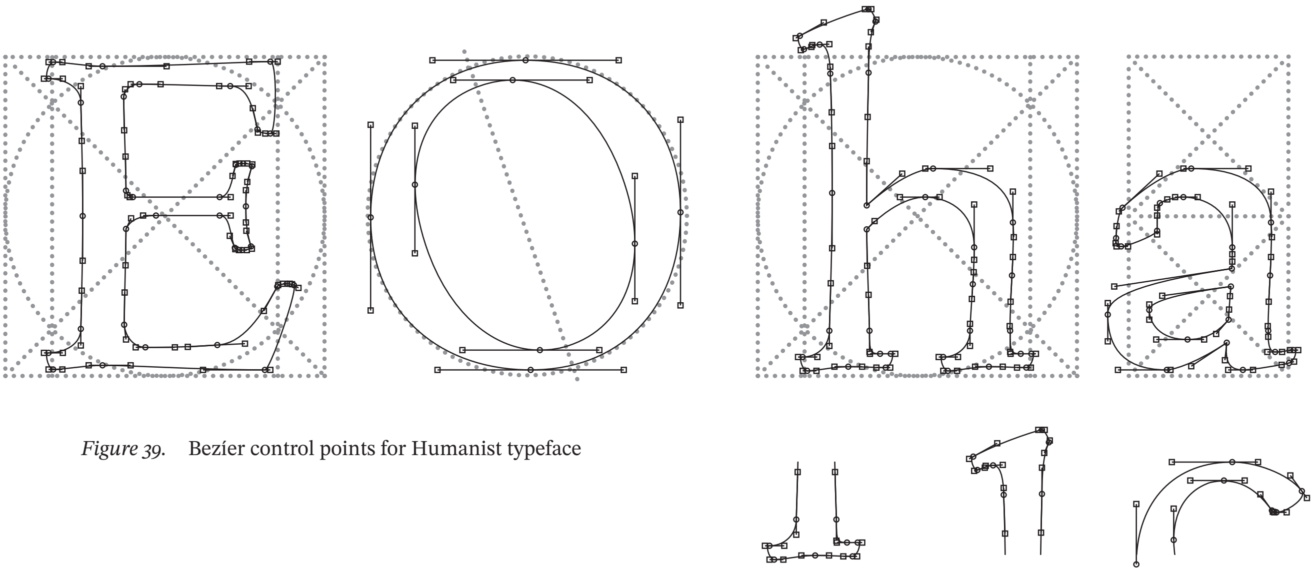


Figure 39. Bezíer control points for Humanist typeface

Humanist typefaces are the original Upright Roman typefaces, often called Venetian due to the geographical history when Venice dominated print production. The true origins however, are attributed to the Renaissance Humanists who combined letter antiqua with Roman Capitalis, and therefore named Humanist typefaces and are heavily influenced by scribing practices.

Proportion

7:10. The proportions (E) to (O) are similar to one another and similarly sized when compared to a geometric circle.

Line Height

With fixed stem widths, there is a large disparity in cap-height, ascender and descender values, however, the x-height is almost identical.

Idiosyncrasies
Stress

19°. The stress of the typefaces is within a single degree of one another.

Contrast

4:10. Contrasts vary; however, this may be skewed by Marco (2015), which has the least contrast (as a typeface based on small sizes) and Adobe Jenson Pro (1996) which has a moderately high level of contrast within the classification.

Stroke

1:7. Stroke-width to Cap-height. Modulation is present, and above which there is a slight skew on stems (particularly visible in the shoulder of (h)).

Serifs/Terminals

Lower-serifs are asymmetrical, almost bracketed on the right side with little evidence of cupping where an upward angle occurs instead. Upper-serifs vary between wedged and those which protrude almost bracketed away from the stem. The terminal of (c) shows a smaller x-height in Jenson with almost a straight edge of the broad-nib pen, all of which end at approximately the same angle (with the exception of a downward terminal of Marco (2015)).

12.1.4. Old-Style

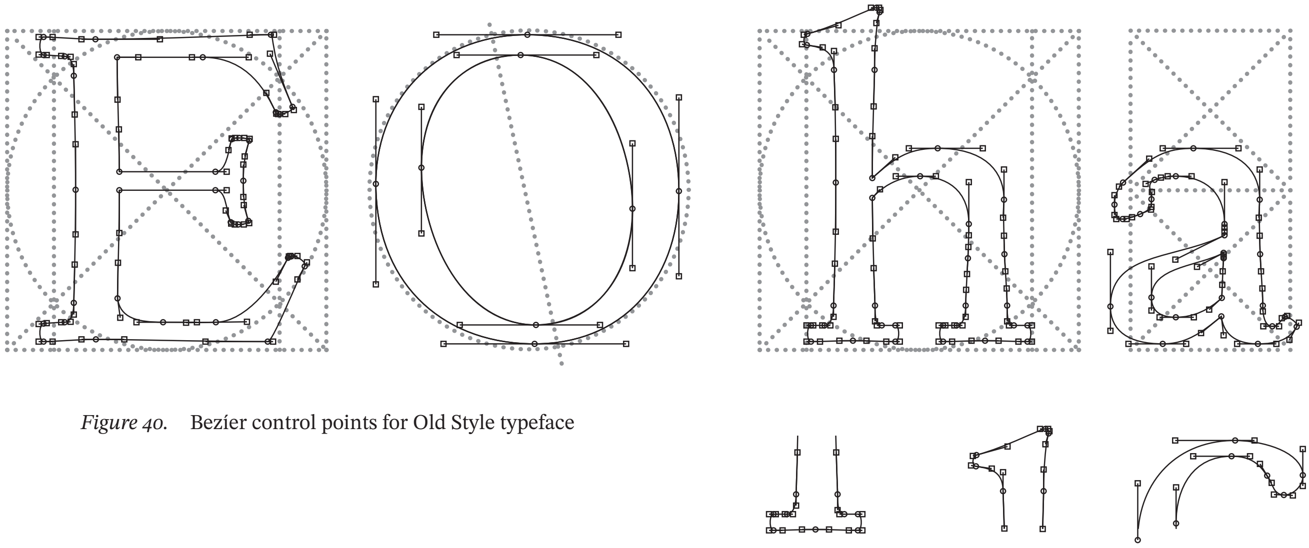


Figure 40. Bezier control points for Old Style typeface

Old-Styles are a refinement of type design with improved technologies and large outreach (with the widespread adoption of the printing press also came adaptations in typeface design). Many forms of Old-Style exist and are often categorised into geographical location such as *Dutch Old-Style* or *French Old Style*. While calligraphic influence still holds true, the marks of the writing utensils in strokes are less evident, particularly in turns and shoulders.

Proportion

6:10. The proportions (E) to (O) are almost identical, yet the appearance of these characters change with contrasts and line heights.

Line Height

There is a big disparity of line heights, particularly in the cap-height. When this measurement is isolated, it can be seen how in actuality the ascender-height is relatively similar and that it is the x-heights and stem widths which amount for the change.

Stress

Average stress: 12°. The stress varies considerably from 10° to 15°.

Contrast

4:10. Instances have similar contrasts, and are the average of the entire study.

Stroke

1:7. Strokes are either slightly or heavily modulated and all slightly skewed from vertical.

Serifs/Terminals

The serifs are of approximately the same design and size within the classification, with some varying levels of bracketing and inclines seen in the upper-serifs. Terminals take a much rounder shape than Humanist forms.

Figure 41. Overlay Old-Style Typefaces

Garamond Premier Pro (2006)
Adobe Caslon Pro (1991)
Renard No.1 (1998)

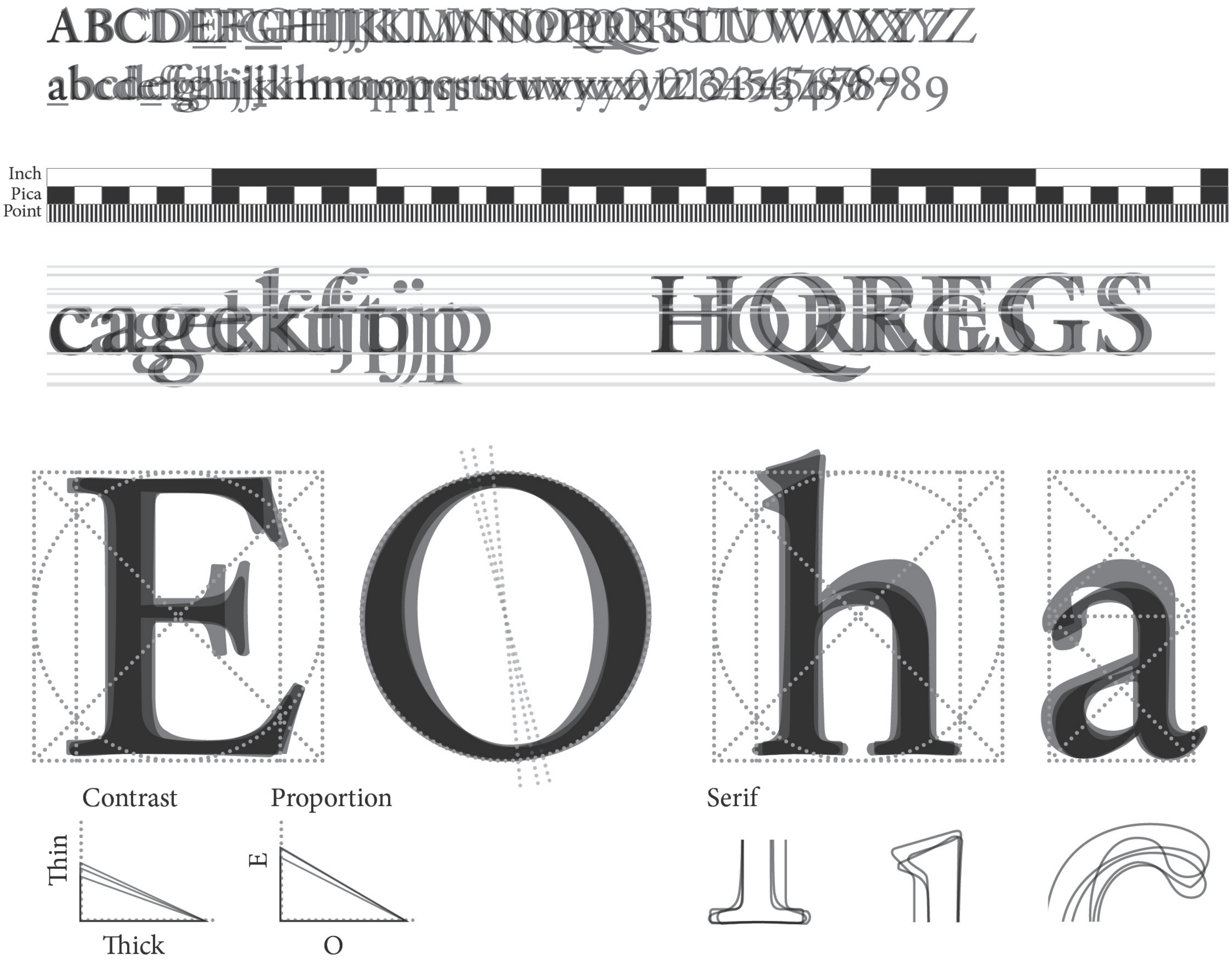
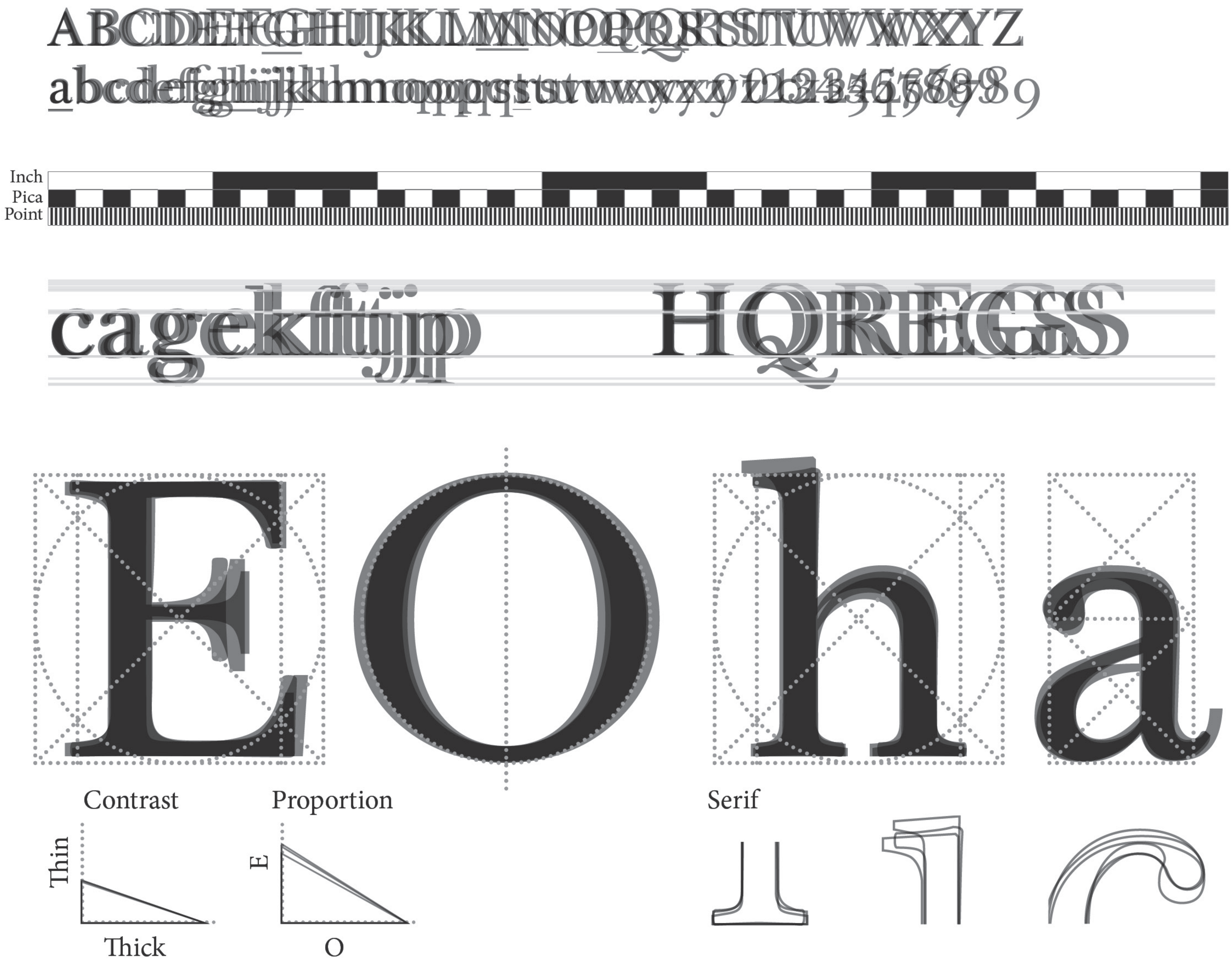


Figure 42. Overlay of Transitional Typefaces

Romain BP (2007)
Baskerville 10 Pro (2010)
Eudald News (1998)



12.2.4. Transitional

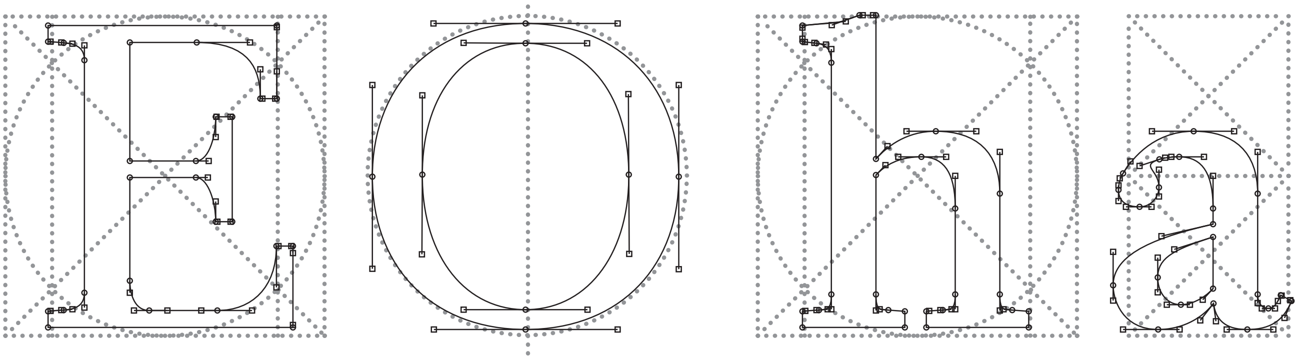
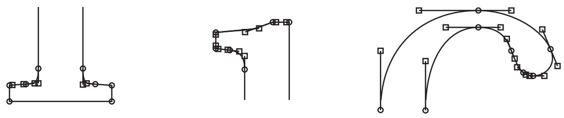


Figure 43. Bezíer control points for Transitional typeface



Transitional typefaces demonstrate a departure from scribing styles and an improvement in technologies. Contrasts increase and letterforms become more geometrically balanced.

Proportion

6:10. The proportions of (E) to (O) are stable and follow similar ratios of both Humanist and Old-Styles, yet the actual widths vary as seen when compared to a geometric circle.

Line Height

When isolating stem widths, the line-heights are very similar, suggesting similarly constructed letterforms. This is enforced when isolating cap-height and comparing the similarities in x-height and ascender-heights.

Idiosyncrasies

The tail in (Q) have entirely different swash styles, for more decorative and creative appearances than Old-Styles and Humanist typefaces.

Stress

0°. All instances have vertical stress.

Contrast

4:10. Stroke contrast is high and almost identical to one another.

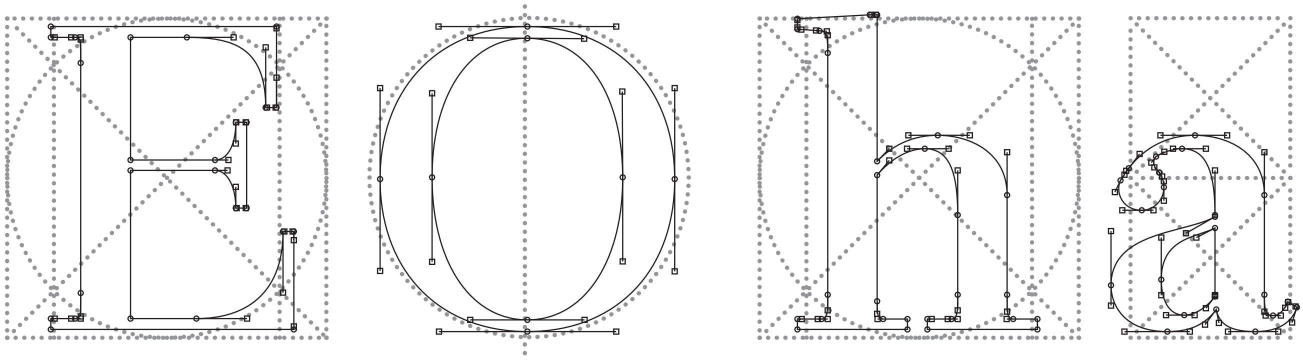
Stroke

1:7. Strokes are almost entirely unmodulated and upright, with exception of Baskerville with slight changes in stem widths and skew.

Serifs/Terminals

Bottom serifs are the same width and height and largely squared in form, where Baskerville 10 Pro (2010) is the only typeface with cupping. The upper-serifs are lightly pitched and flat, cupped and with an angle of inflection for Eudald News (1998). The terminals end in approximately the same position and are rounded with exception of Eudald News (1998) that has a ball terminal.

12.3.4. Modern



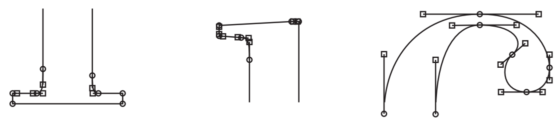


Figure 44. Bezíer control points for Modern typeface

Modern typefaces push the boundaries of precision in print and paper by pursuing extremely narrow forms with hairline serifs and extreme contrasts to create the most elegant of characters. Within the examples are a standard Italian or French Modern, a Modern typeface based on small optical sizes, and a Scotch Roman typeface which generally reduce in contrast and stroke style.

Proportion

7:10. The (E) becomes far wider, in part by lengthy serifs and otherwise by a trend of narrowness of the (O), or otherwise in circular form and a reduction in overshoot.

Line Height

The ascender-line is almost entirely abandoned in place of a shared ascender and cap height. There is very little difference between the typefaces regarding line-heights.

Idiosyncrasies

The letterforms are similar in design. When viewing the (a) of overlayed Modern types, it can be seen how early Grotesk styles may have been based on Modern letterforms.

Stress

0°.

Contrast

2:10. High contrast and extreme contrast.

Stroke

1:6. Strokes are unmodulated, with the exception of Bodoni Six, which may replicate the actual printing matrixes or impression transfer.

Serifs/Terminals

Serifs are of approximately the same widths, however the thickness varies. The upper serif is mostly flat, other than the case of the Scotch Roman. The terminals adorn ball terminals and the (G) often with both spurs and beard.

Ambroise (2001)
ITC Bodoni Six (1994)
Miller Text (1997)

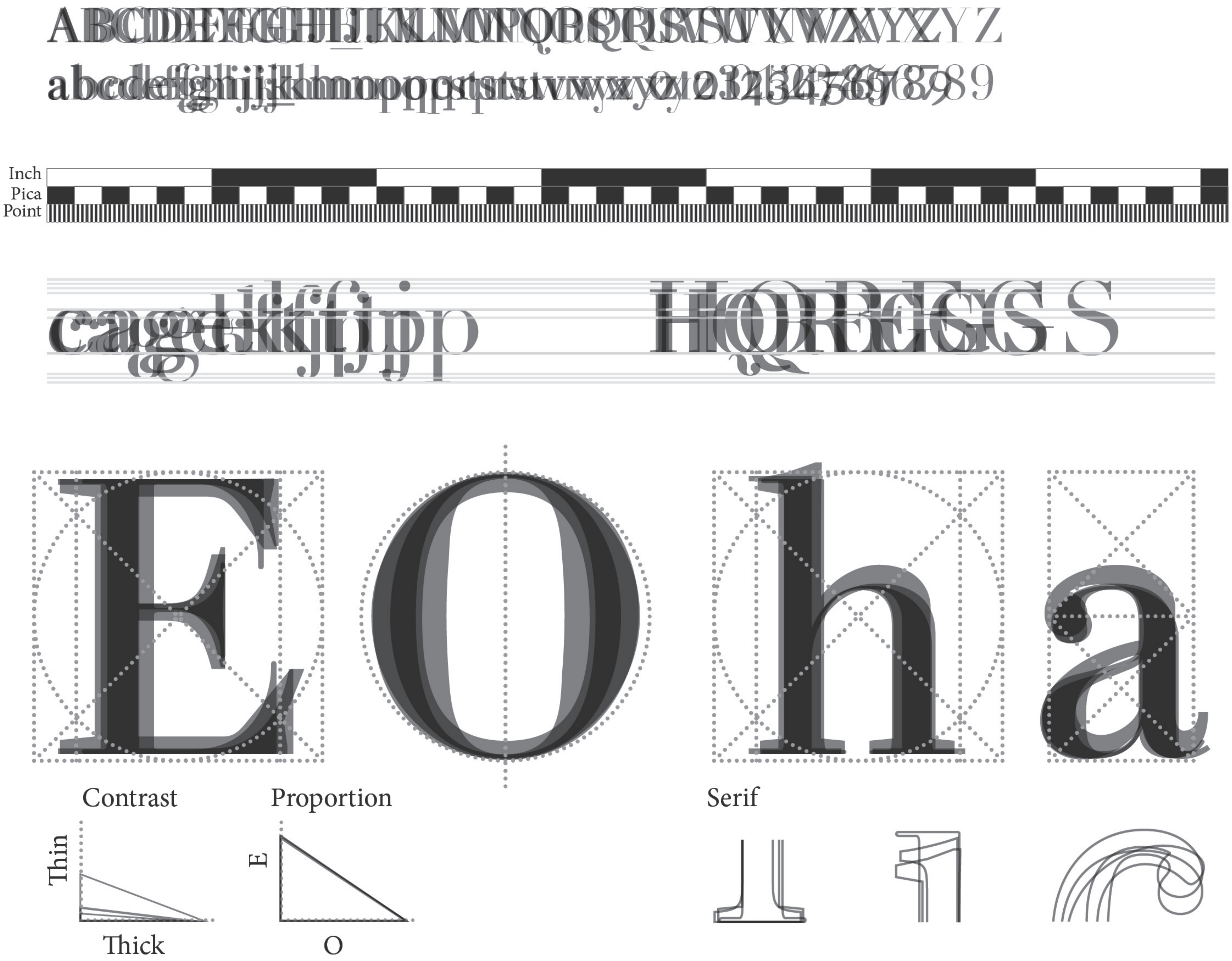
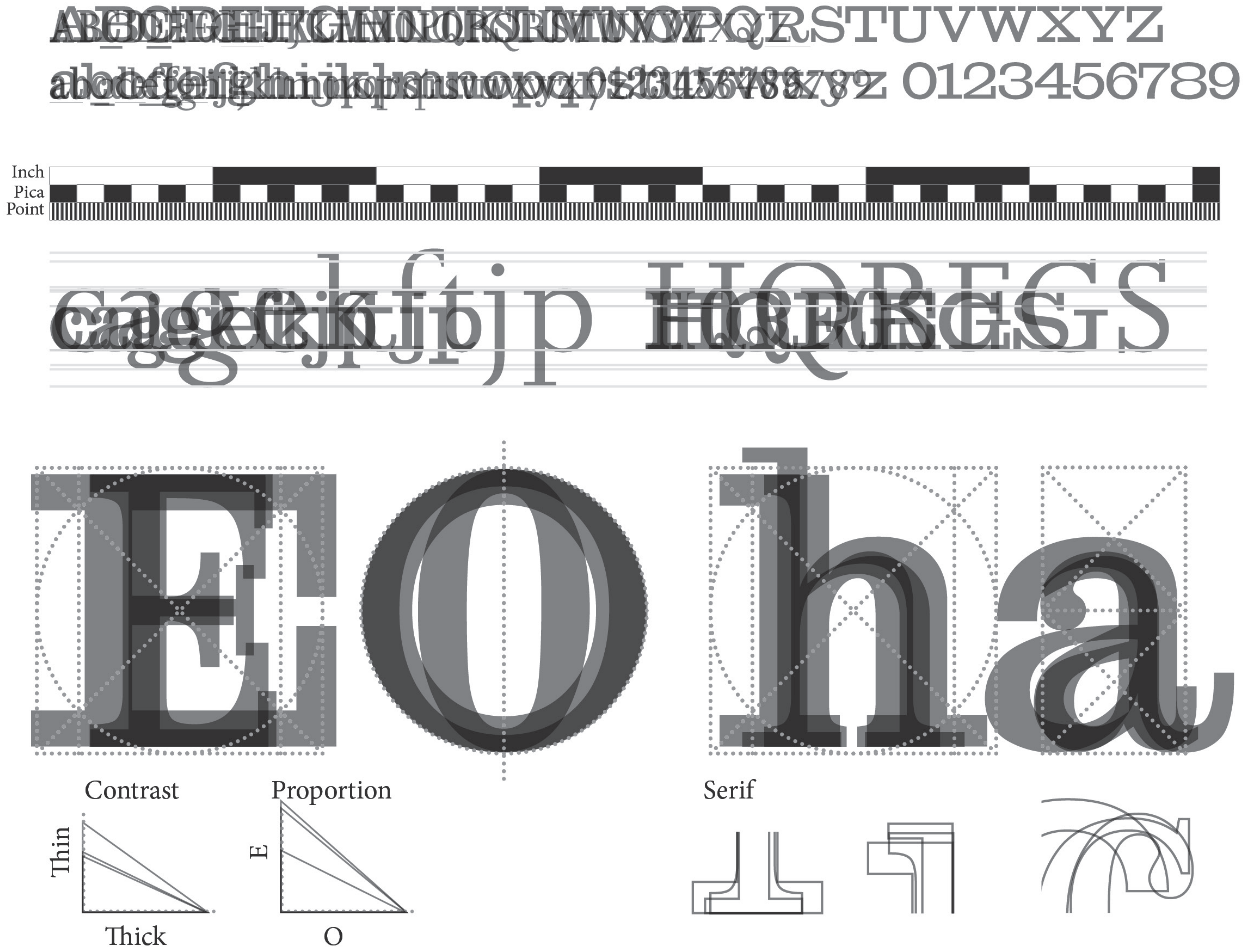


Figure 46. Overlay Slab Serif

OL Egiziano (2003)
Consort (1994)
Joanna Nova (2015)



12.4.4. Slab-Serif

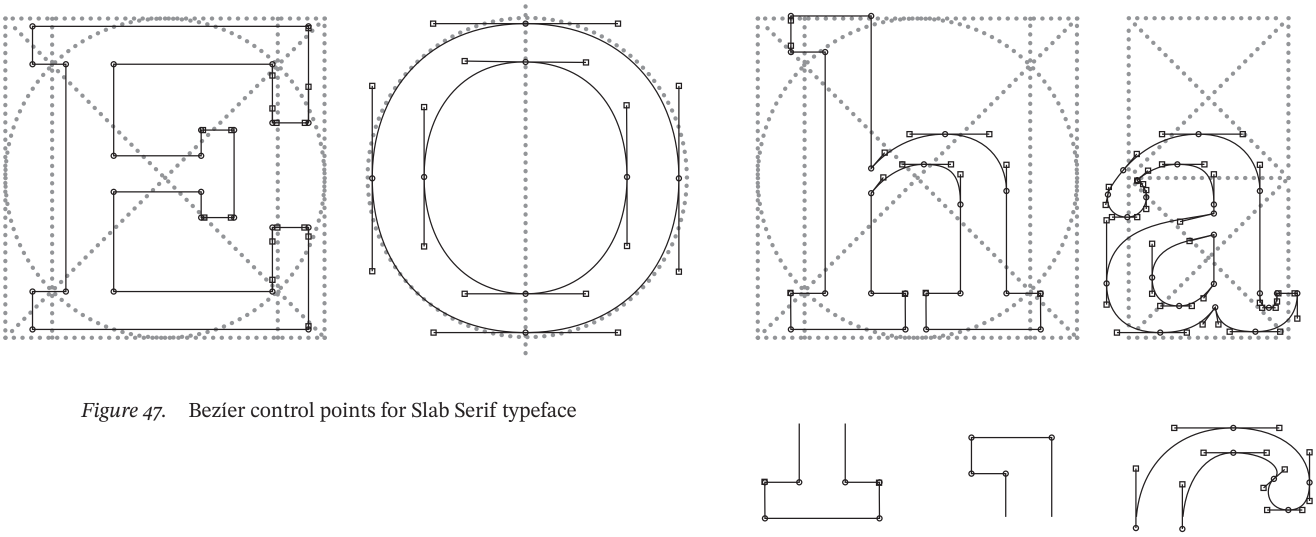


Figure 47. Bezíer control points for Slab Serif typeface

Slab-Serifs are born in an age of marketing and a continuation of making Modern typefaces bolder (which primarily became fat-faces); in Slab-Serifs weight is added to all strokes and serifs as opposed to a fat face which may still have extreme contrast between thick and thin strokes. This is possibly the most diverse classification when the widths of the letterforms and contrasts are compared.

Proportion

7:10. Proportions and widths vary dramatically between wide and condensed, and the comparison sees a difference in almost doubled width of (E) to (O) proportion, of which Joanna makes this difference.

Line Height

When considering a fixed stem width, the line heights vary considerably with the heavier Slab-Serifs having a cap-height approximately the same level as the x-height of a narrow Slab-Serif.

Idiosyncrasies

The upward-turned lower terminal of (a) becomes a common feature.

Stress

0°.

Contrast

6:10. Contrasts vary between medium contrast to approaching no contrast.

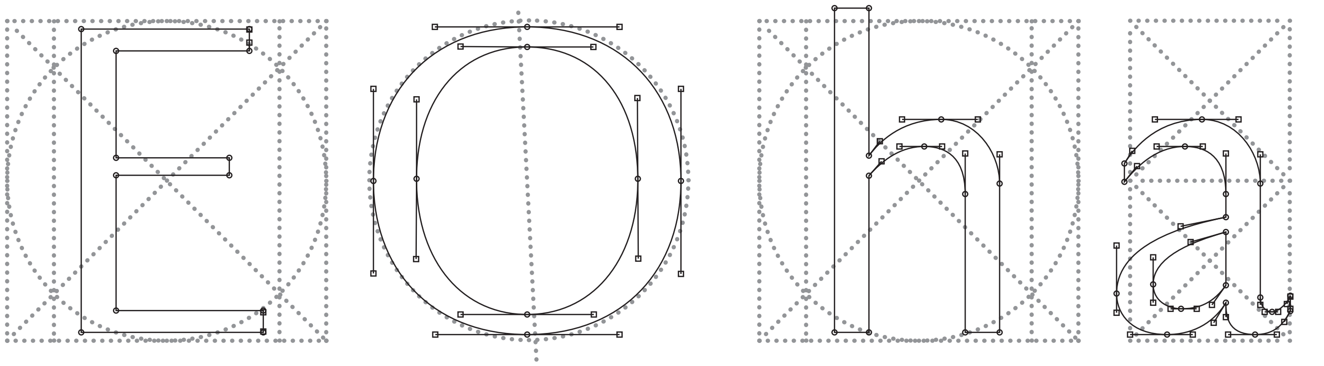
Stroke

1:7. Strokes are unmodulated and upright.

Serifs/Terminals

Serifs are generally wide and with significant depth. Consort does is not bracketed and belongs to the Clarendon subclassification of Slab-Serifs. Terminals are entirely mixed between a lack of ornamentation, ball terminals and spurred terminal.

12.5.4. Humanist Sans-Serif



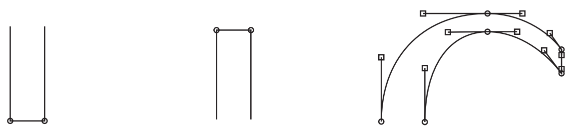


Figure 48. Bezier control points for Humanist Sans-Serif Style typeface

The Humanist Sans-Serif classification is the youngest of the classifications, its terminology was birthed by Hermann Zapf in the second half of the 20th century, regardless of Humanist Sans-Serifs already in circulation at the time. They have proportions which reflect Old-Styles, and for this reason are the first Sans-Serif classifications to be investigated due to this proximity to serif styles.

Proportion

5:10. The proportion of (E) to (O) differ, as does the width of the (O), however, what can be seen from a fixed cap-height is a relative similarity in letterforms.

Line Height

Line-heights are seen to vary significantly, with ascenders both above and equal to the cap-height.

Stress

0.3°. On close examination, there appears to be a slight deviation from vertical stress in Sean (2011)

Contrast

7:10. Contrasts are extremely varied from mono-linear to high contrast.

Stroke

1:9. Strokes show a mixture of both modulated and unmodulated strokes.

Serifs/Terminals

No serifs, however, cupping exists at the lower and upper strokes. The angle of terminals are mixed, but tend to end in a vertical configuration.

Figure 49. Overlay Humanist Sans-Serif

Gill Sans Nova (2015)
Optima Nova (2002)
Sean Sans (2011)

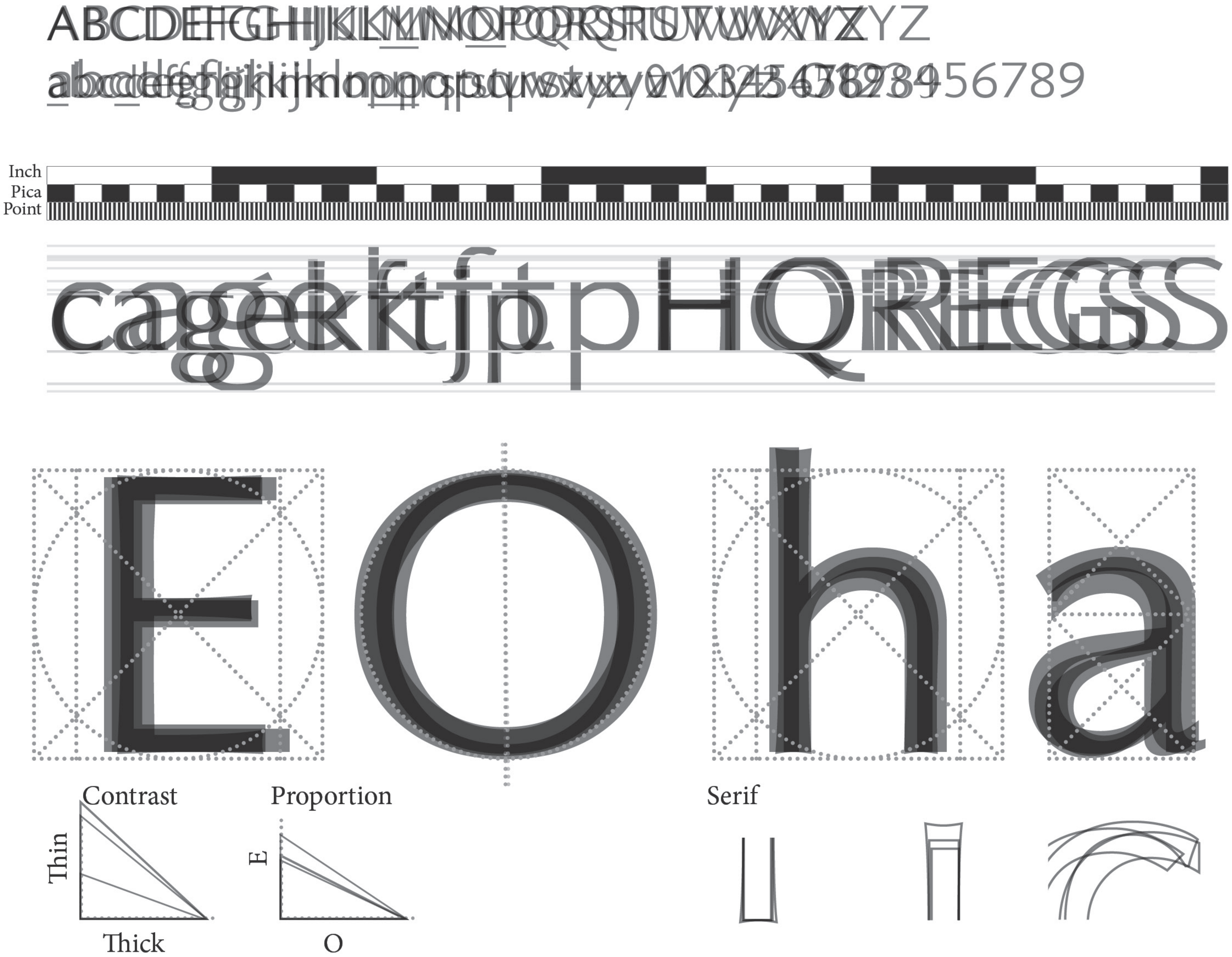
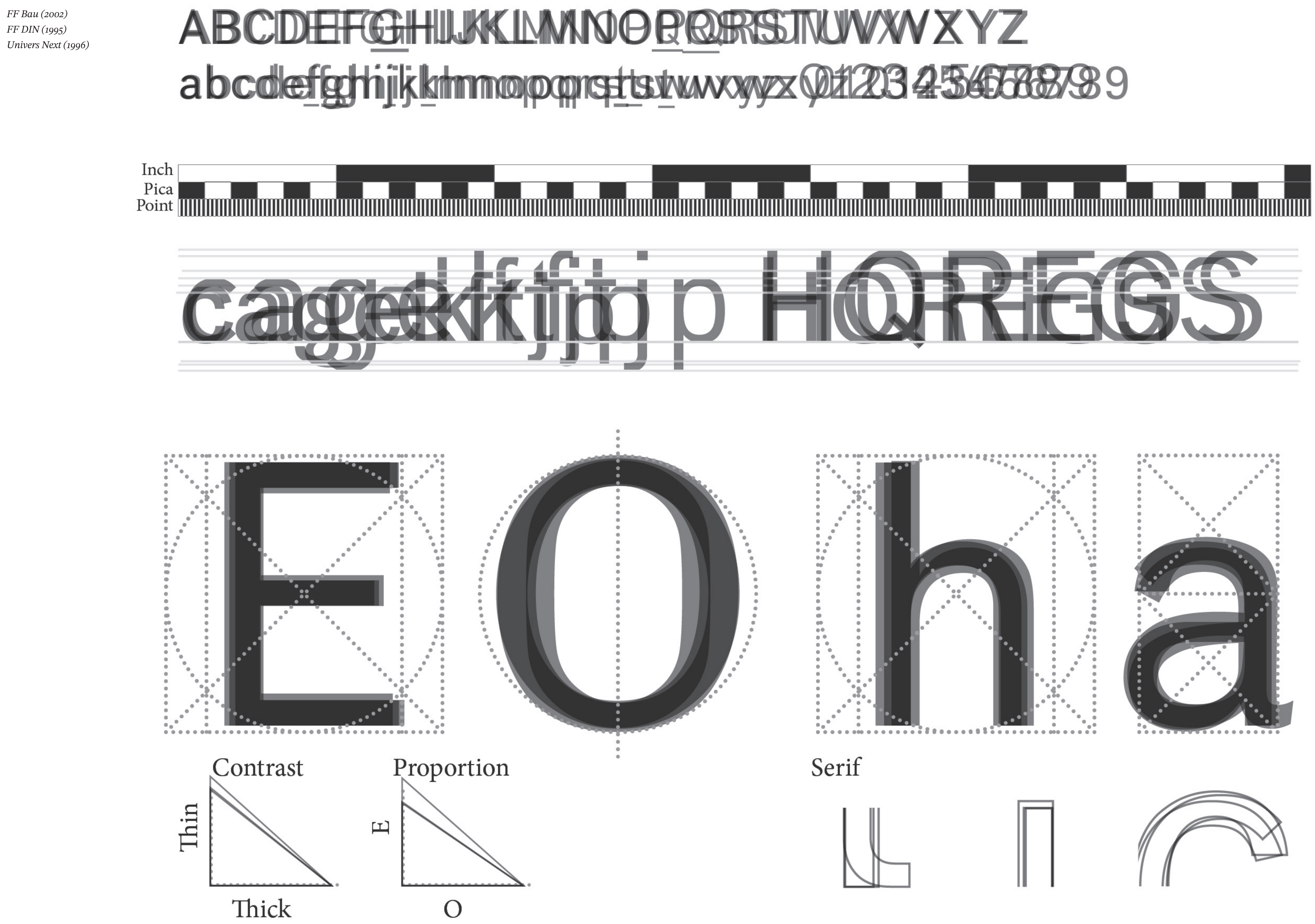


Figure 50. Overlay Grotesks



12.6.4. Grotesk

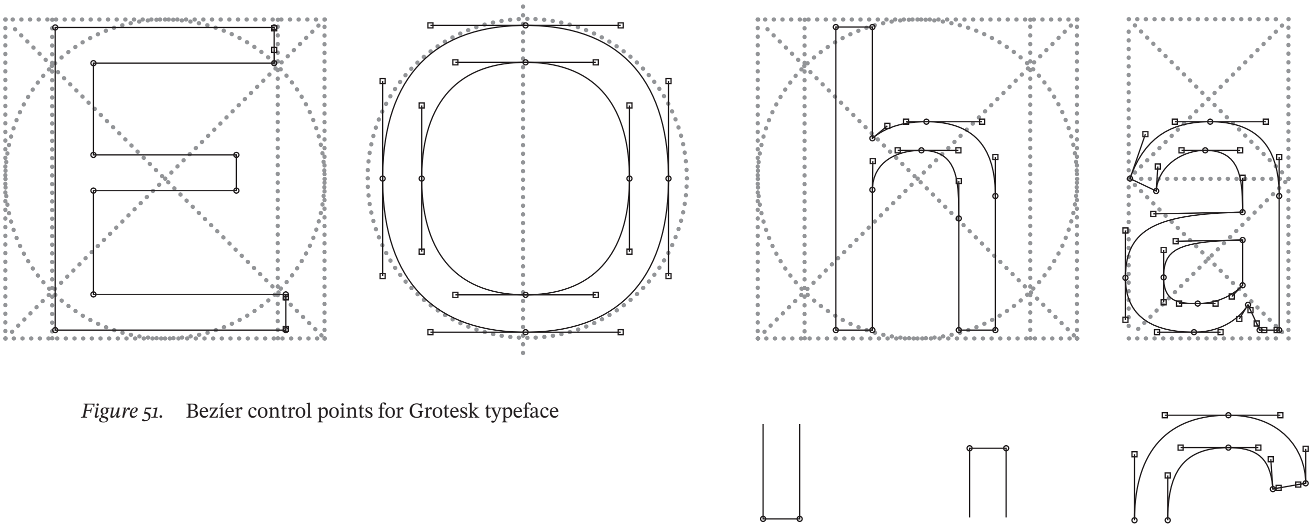


Figure 51. Bezíer control points for Grotesk typeface

Grotesks (also known as *Grotesque*, *Gothic or Doric*) are a continuation of typefaces created for advertising purposes in the mid-19th century. The classification name is attributed to what was perceived as crude or strangely designed typefaces. The principle is in fact the removal of serifs from Slab-Serifs, or the same removal of serifs and thickening of strokes of a Modern typeface. The uses of Grotesks expanded in the early 20th century, and refinement of typefaces leads to a subclassification N*eo Grotesk* which are far more suitable for smaller text sizes than the early advertising Grotesks.

Proportion

8:10. The analysis demonstrates a wide (E) to a narrow (O), but is slightly deceiving due to FF DIN (1995) having condensed letterforms and yet a closer proportion of (E) to (O) than the other Grotesks.

Line Height

The line heights vary, however there is a trend of large x-heights and relatively shallow descenders. Ascenders and cap-height meet at the same level within typefaces.

Idiosyncrasies

The lettershapes are all very evenly matched even when considering the narrow nature of FF DIN (1995).

Stress

0°.

Contrast

8:10. Contrasts are extremely similar and are almost entirely mono-linear.

Stroke

1:8. Stroke is regular and upright.

Serifs/Terminals

Sans-Serif, the terminals have no ornamentation and havour a horizontal angle at which they end, the approximate location of the terminals seen in (c) are similar. Some lower stems adorn turns or feet.

12.7.4. Geometric Sans-Serif

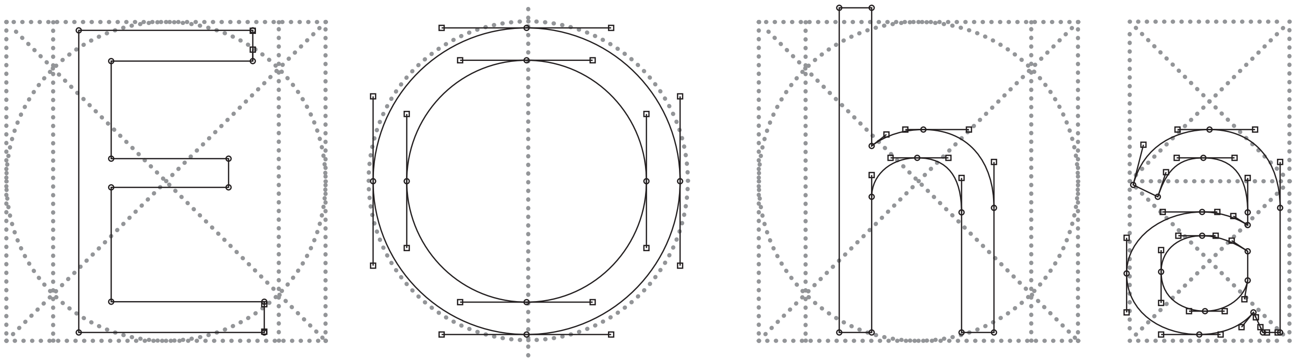
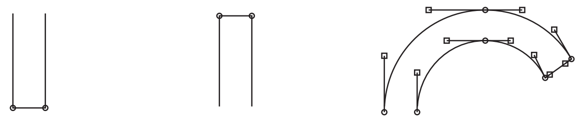


Figure 52. Bezíer control points for Geometric Sans-Serif Style typeface



Geometric typefaces intend to create alphabets in rational geometric form – a distancing from the calligraphic hand in favour of simplicity, which distinguished them from letterform design of the Renaissance or Transitional eras where geometric forms were used as tools to interpret calligraphic forms. Experiments to simplify the alphabet has seen Geometric typefaces lack a full 52 letter alphabet, have overly-experimental letterforms and deviate a substantial distance from ordinary legible characters.

Proportion

6:10. The (E) to (O) ratio generally follows Roman Capitalis proportions with the exception of Gotham (2000). In all cases (O) closely resembles a true geometric circle with slight deviations, both wider and narrower than a geometric circle.

Line Height

All instances have differing ascender and cap-heights with large ascender-heights. X-heights are tall and descenders relatively short. Gotham (2000) is completely unique in its line heights with an exhaggerated x-height and shallower descender.

Idiosyncrasies

The first appearance of the single storey (a).

Stress

0°.

Contrast

9:10. The lowest contrasts of any typeface classification.

Stroke

1:9. Regular upright including little contrast in stroke between shoulders and stems.

Serifs/Terminals

Sans-Serif. Terminals follow a trend of similar 45° angles.

Figure 53. Overlay Geometric Sans-Serif Typefaces

Futura ND (1999)
Semplicatá Pro (2011)
Gotham (2000)

7.2. Discussion

Figure 54. Letter (h) of entire sample.

The study compares a fixed character set of typefaces scaled to uniform values for a level comparison. The selection criteria enabled the typefaces to exist in the same format (digital vector) and be accurate representations of historical interludes; where several renditions of the same typefaces exists the selection process permitted those based on smaller text sizes. The diverse range of typefaces of various styles are displayed in a manner that allows for precise and accurate measurement and observation. The observations are transcribed to outlines which imitate the characteristics per each style group in order to assess compatibility in OpenType Font Variations format and create meaningful relationships between master outlines.

A holistic view of the overlayed typefaces with fixed cap-heights provides ample demonstration that certain principles unite letterforms across the typefaces as suggested by Gerrit Noordzij, particularly evident when observing the counter in (h) *(Figure 54)*. However, a view of all data enforces the variations in typographic dimensions (stroke-with, letter-width, contrasts and mean-lines), even when considering a single counter in an isolated letterform. Furthermore, the loose relationship in aperture of (a) is interfered by a single-storey (a) from Futura (1999), a phenomenon which would be compounded if the letter (g) was considered which occurs more frequently in a single storey configuration than (a). As such, a comparison of all typefaces provides a general impression of letterforms, but greater value is found in the comparative ratios of stress, proportion, and contrast that show trends and minimum and maximum values in a simple manner.

Figure 55. The averaging of 900 typefaces (top) to create *The Average Font* (bottom) by Iotic, found in (Sayers, 2011).

Creating a variable typeface without segregating the data further could be accomplished by either using the minimum and maximum values, or through a law of averages. A demonstration of the latter was conducted by Dan Sayers (iotic) who created *The Average Font* (*Figure 55*), a single alphabet that combined each letter from over 900 typefaces (Sayers, 2011). For precision it is required to divide the data into smaller groupings for letterforms to become more recognisable and comparable and act as a descriminator as used by Hayashi, Kohtaro, & Uchida (2019).

Reducing the sample size to three typefaces allows for more accurate comparisons and doing so by the Vox classification model increases their similarities particularly when considering the chronological tendencies it follows, and thus peculiarities that exist due to production techniques of the time. In theory this corresponds to smaller design spaces specific to each classification and dictated by the samples present; in practice the characteristics of each typeface are less predictable and only evident when assessing the letterforms of each typeface individually. Common patterns exist such as single and double storey (a) and (g), or whether (C) has a lower terminal or a final, but idiosyncrasies specific to typefaces are challenging to predict such as the erroneous (g) of Ambroise (2001) or original Futura (1927) drafts by Paul Renner that do not follow a conventional heartline. The inclusion of such phenomena into a variable framework can be accomplished by glyph substitution; however, as these do not exist beyond a single typeface or style classification, the appearance of the characteristics would need be imagined (or ignored) for the remaining masters of the variable font. The inclusion of such anomalies increases the typefaces versatility, yet is excessively complex to construct requiring all alternative letterforms to be compiled into the design space (practically creating separate, relatable design spaces for each letter alternative) and accessible via toggle axes per character.

Figure 56. Letter (g), Abroise (2001).

Viewing the data by classification show patterns in contrast, proportions, and serifs and terminals. While these are evident in an overview of all typefaces the trends per style classification are enforced when viewed separately with varying levels of deviation from one another. For instance, the Transitional typefaces are decidedly similar to each other in contrast, proportion and even terminal design, yet observations of Humanist Sans-Serifs show a great disparity. Exceptions to trends can be investigated by isolating individual typefaces that exemplify or deviate from trends within a classification, as noted with the varying heartlines of letterforms.

The deductions made by analysing typefaces within a classification system services the exercise of drawing outlines of each style paradigm. By using control characters as defined by Debra Anne Adams (1986), the majority of a typeface's appearance is efficiently represented. This practical implementation of the data satisfies the requirements of a Font Variations file, able to act as master outlines through equal and similar geometries and thus allowing for interpolation. Using measurements based on the data of classifications to create the master outlines increases the resemblence, yet are not benchmarked across other styles and therefore vary in structure.

The successful interpolation of these instances may in part satisfy a history of type design in an OpenType Font Variations format, however, they lack orientation within a common design space and thus sensible control. Axes can be created to link compatible outlines designed according to style classifications, yet the behaviour of the interpolations may be haphazard without predetermining how the axes will influence the shifts in outlines. This process begins with determining the number of axes and assigning each set of outlines a corresponding location (such as minumum and maximum values of an axes). In this way a single axis can serve as a generally chronological timeframe based on typeface classifications beginning with the Humanist outlines and concluding with Geometric or Humanist Sans-Serif outlines (*Figure 57*). This creates a smooth transition between outlines, but each intermediate master only interplolates with a pair of outlines that act as minimum and maximum intervals of the axes to that given master.

Figure 57. Compatible outlines arranged by single axes.

Expanding a design space using the existing outlines can be achieved by separating Serif and Sans-Serif typefaces and equating Serif styles to approximately equivalent Sans-Serif typefaces such Humanist to Humanist Sans-Serif styles (*Figure 58*), not unlike Robert Bringhursts' classification model. There are limited arrangements of masters and axes to do so and the lesser compatible arrangements result in erratic node movements that lead to illegible instances.

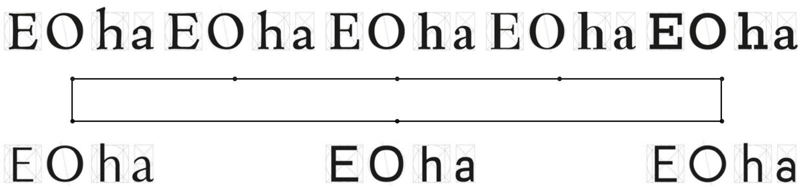


Figure 58. Compatible outlines arranged by two axes.

This shows that for increased interactivity to adjust typeface characteristics within and/or between style groups, axes must be disconnected from a chronological axis in favour of characteristics, and the outlines must be designed to respond accordingly. AmstelVar (2016) by David Berlow can be described as a large typeface family made interactive by Font Variations, and as such uses some conventional axes (weight and width) that can be considered applicable to other typefaces. Three axes control the vertical metrix of AmstelVar (2016), which scale the length of the strokes and Bézier curves while preserving the values of terminals and serifs. The remaining axes then influence the stroke shape and contrast, including a system which independently shifts either the inside, or outside of a curve. This control of the stroke allows a user to influence AmstelVar into *behaving* as Transitional, Modern and Slab-Serif styles, and even as a Decorative style with *reverse contrast*. This demonstrates how a design space can expand to include separate type classifications, but falls short of addressing critical design features such as serif design and stress that could increase the range of style classifications available.

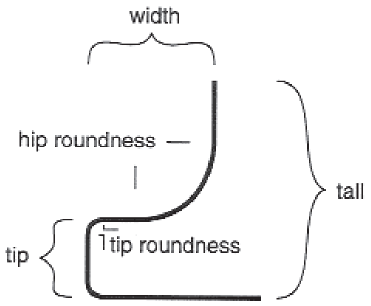


Figure 59. Serif Digits of Panose 2.0 (top) found in (De Laurentis, 1993).

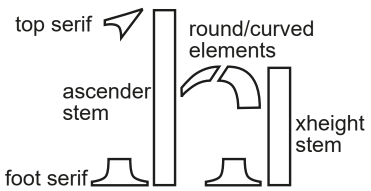


Figure 60. Basic Structure Elements, found in (Hu, 1998).

Investigating serifs as a separate entity can aid in providing flexibility to a user while using a fixed skeleton and can imitate various style classifications as a result. For example, a Grotesk Sans-Serif typeface (e.g. Akzidenz Grotesk (1898), which originate from the reduction of contrast and serifs of Modern typefaces) combined with heavy serifs can imitate a Slab-Serif (e.g. Memphis (1929)) and a Clarendon (1845) sub-classification when the serifs are bracketed. To achieve this, an axis is required for a magnitude of the desired serif and another for the amount of bracketing. A Panose 2.0 measurement system (*Figure 59*) can be adopted in OpenType, providing axes for serif width, height, roundness, and bracketing (De Laurentis, 1993). This would involve 16 masters, reduced to 11 by extrapolating the shapes of the serifs when they lack in width and height. Creating axes for serif control can be achieved by separating them from the letterforms themselves as primitive parts in a similar manner to Changyan Hu's *basic structure elements* (*Figure 60*) (Hu, 1998). Doing so allows for the serifs to be designed separately to the letterforms, however, attention must be given to stem widths and terminals to ensure the geometries correctly align. Applying the serif transformations to an axis which contains the four instances (Humanist, Modern, Grotesk and Geometric) quadrouples the number of masters (*Figure 61*). Appyling serifs this way only a satisfies a small number of style classifications, but the behaviour of the bracketing can emulate the end of strokes as fine brush strokes or wedge serifs.

Figure 61. Fixed heartlines with no value for serif width, serif height, and bracketing (left) augmented by master serif outlines (middle), and resulting typographic style (right).

The manner in which serifs have been isolated from overall letterforms to relate to specific axes can be expanded to other repetitive shapes. Since letters can be broken down into individual strokes that are shared with other characters, a component library can be similarly compiled to form a succinct description of an alphabet. Once a component part has been sensibly created it aids in rapidly adjusting the design of an entire alphabet as practiced by Philipe Coueignoux, Debra Anne Adams, and Changyou Hu (and even with tools that created metal type such as counter-punches). Adjusting a relatively small amount of data results in significant change; for instance, when a stem is paired with a bar, turn, or bowl, the contrast of numerous characters (or the entire typeface therein) can be dictated by the stroke supporting the stem (the bar etc). While this process does not reflect the subtle differences that exist between letters which share similar strokes, it provides a basis of generating typefaces consistent in style. The number of components identified (*Annex 3*) to build an alphabet this way that supports OpenType 1.8 interpolation (with changes in stress, contrast and serif size) is: a horizontal bar shared between both cases (present in 15 characters), 23 components for uppercase letters and 19 for lowercase. There is little overlap between the cases due to differing stroke widths requiring compatible junctions between component shapes. Similarly, there exist many components such as the lower serifs which require duplicates that only differ to match junctions, particularly when considering diagonals and changes in contrast, or angle of diagonal stroke to accomodate the serifs. Furthermore, there exist components that are not shared with other characters such as the link of (g) or beard of (G), which simply may not be present in the typeface at all.

The need to limit the volume of typeface specimens in the research means that some type design styles and attributes are not identified such as the previously mentioned wedge serifs. Increasing the range of patterns features can be acheived in numerous ways such as employing a different classification system (*Figure 62*) or including contemporary typefaces that are idiosyncratic but can be regularly classified. Furthermore, employing an equal number of typefaces per classification neither reflects the popularity nor diversity of styles (which is problematic if the particular typeface or style lies outside the min-max values of the study sample). The possibility exists that the arrangement of masters and axes inadvertently (or deliberately) allow the freedom to control forms as demonstrated by adopting the Panose 2.0 serif definitions.

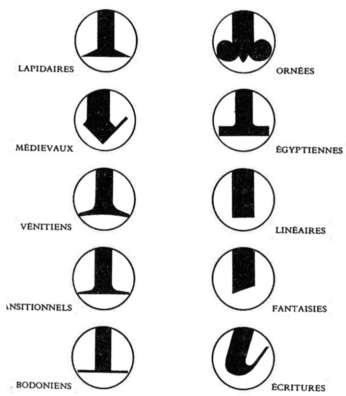


Figure 62. Novarese's typeface classification (1957) shows a lack of diversity in the data within the study with many serif styles omitted, found in (Lalliazon, 2021).

The manner in which the data was compared brought similarly designed typefaces together and identified patterns within and across classifications. The raw data provides a basis in which to create relatable outlines and for use as axes values. Visual comparison of the data required standardising measurements, but global comparisons are few due to the intricate differences between typefaces. While the stroke-width of stems had been collected per typeface, the minimum stroke was neglected, leaving only the ratio in contrast and no definition of the weight or width, the latter of which can be suggested by proportions between (E) and (O), but requires a relationship between (O) and a geometric circle.

To be able to include a greater number of typefaces accurately as master outlines more data is required, and by only using the data available assumptions needed to be made for a final variable typeface such as a fixed skeleton, the apropriating of previous parametric models, or the restructuring of axes to allow for greater interactivity with a design space and designing abstract masters that can generate style instances by interpolation. It can be speculated that value is added by prioritising the influence of axes for greater control for a desired instance than a historically accurate typeface with a weak relationship to the design space.

8. The Universal and Unified Typeface

Achieving a style-fluid typeface in OpenType Font Variations can result in a shared, open-source technology easily operated by software and users, able to reproduce typefaces with relative ease and unlimited flexibility. The implications of this is the potential to replace existing libraries of typefaces into a default type selection process, possibly making existing typefaces redundant (a concept which has been experimented in past). The combination of unanimous use and flexibility in style delivered by the Font Variations framework can effectively meld the differing opinions of Robert Bringhurst and Robin Kinross.

Bringhurst (1997) describes typography as *"the craft of endowing human language with a durable visual form".* He describes in many analogies how type affects the perception and enjoyment of those digesting content and that variety in typefaces is of utmost importance. He clarifies that *"the original purpose of type was simply copying,"* emphasising that legibility is paramount (Bringhurst, 1997, pp. 11, 18). In contrast to Bringhurst's claims of power that typographic style provides through diversity, Kinross (2002) entertains a concept for an *ideal* typeface *"that meets all needs: of composing and printing techniques, of legibility, of aesthetics, of phonetic and semantic representation"* (Kinross, 2002, p. 233). The creation of such an ideal typeface would result in its unanimous use: the abandoning of choice in favour of a default, globally applicable, universal typeface. He suggests that Romain du Roi (1693) may have been the first example of a universal typeface given its objective to be ideal in form and fabricated at all required sizes (supported by an oblique version) (Kinross, 2002). Yet it is in the 20th century when most attempts at a universal typeface are seen as a result of inter-war hardships where standardisation is an economic justification. The atmosphere of the time becomes one of *"shedding all unnecessary baggage, returning to zero point, and proceeding rationally, that the idea of a universal typeface received its fullest exploration"* (Kinross, 2002, p. 235).

8.1.1. Universal typefaces

Herbert Bayer created Sturm Blond at the Bauhaus in 1925 which was an experiment at a universal typeface by removing excess. The letterforms are constructed entirely from geometric shapes devoid of calligraphic influence and created in a single case. Challenging the use of the uppercase letters in German dates back to The Brothers Grimm and removing it entirely became commonplace by German modernist designers looking to introduce an entirely new orthography in line with the *machine age*. Exploration of geometric letterforms also became common, the most successful being Paul Renner's Futura (1927); and although Geometric in style, Futura (1927) did not depart entirely from traditional type design principles as demonstrated by the use Roman proportions in uppercase and reduced x-height of minuscules (Eisele, 2017). Kinross describes Futura as *"the typeface that best represented the ideal of geometrical construction, but with refinements and modifications that make a typeface actually work when set as text (as opposed to seeing the characters in splendid isolation)"* (Kinross, 2002, p. 239).

Contrary to reducing the alphabet, Adrian Frutiger broadened the capabilities of a single typeface with Univers (1957). It was conceived with a breadth of variants as a *family*, presented in the manner of the periodic table and having the capability to *"meet all needs in any typesetting system in any language using Latin characters"* (Kinross, 1984, p. 23) that *"in due course non-Latin versions (including Cyrillic and Japanese) appeared"*. Universal by name, the typeface is *"standard, neutral, machine-determined,"* capable of being assigned to most tasks (Kinross, 2002, pp. 241, 243). This flexibility of application combined with a neutral rhetoric straddles between a universal typeface and power through diversity.

Figure 63. Sturm Blond (1926), Universal Typeface (Joost Schmidt, (1925)[Left], Futura (1925), New Alphabet (1967), Single Alphabet (1929) [Right], Found in Kinross (2002).

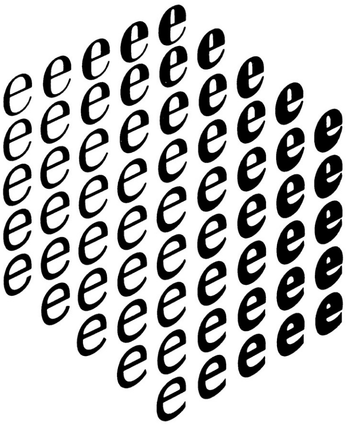


Figure 64. The Noordzij Cube, found in (Noordzij, 2005, p. 79).

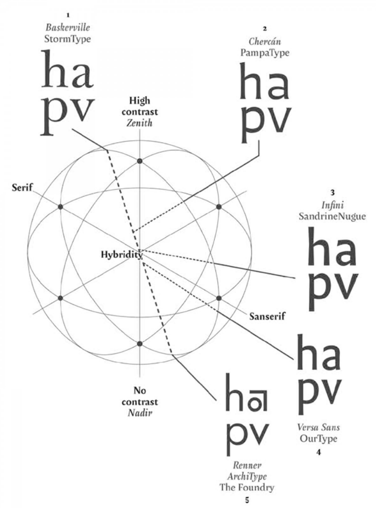


Figure 65. The Typographic Vault that represents *"types of contrasts, historical periods of styles, classifictions, and any design in general."* (Pizarro, 2019).

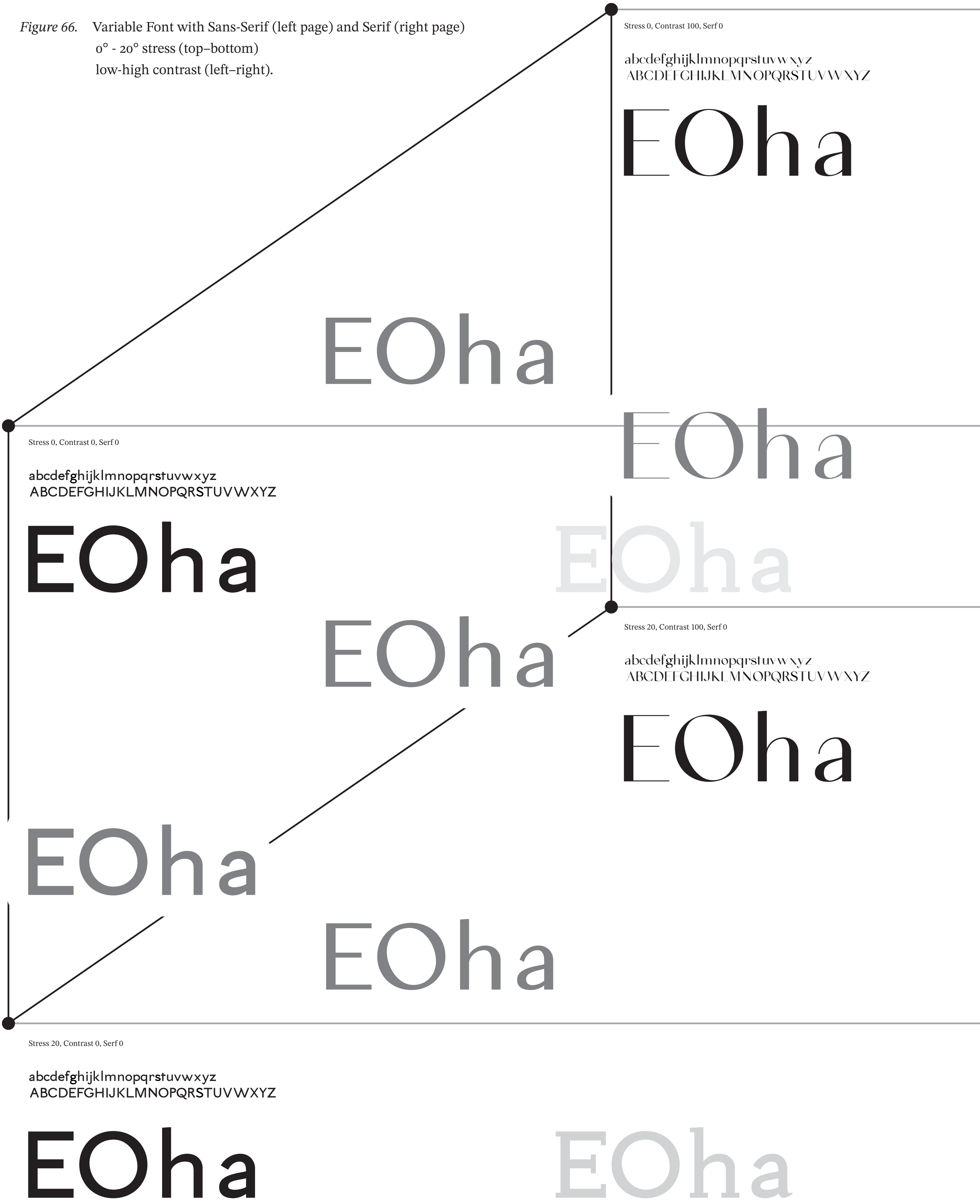
8.2.2. Combining Type

By leveraging digital technology, a universal typeface need no longer be considered as a static instance and can instead be flexible in appearance as demanded by a user and computed in real time. Where a typeface such as Univers (1957) can be applied to most tasks, the hypothetical universal typeface's style can be adjusted to suit the intended context. The processing power of technology allows this opportunity, however, the manner in which a typeface appears and interacts requires careful planning and remains complex.

Attempts for flexible typefaces have existed since METAFONT in 1977 and such parametric systems can refer back to handwriting. Gerrit Noordzij was proactive in type design during the dawn of the digital age yet his theories are firmly compounded by the human hand, stating that *"by programming design we can achieve the fluidity of handwriting"* (Black, 2017). His school attempted to improve legibility by defining parameters to make typography responsive to various data. The *Noordzij Cube* (*Figure 64*) is a model that demonstrates his stroke theory and the change of contrasts by translation, expansion and rotation. It reflects a design space where a number of differing typographic styles are visible and is transferable to a digital environment, accomplished both by Peter Karow and Gerrit Noordzij using IKARUS as an interpolation engine (Blokland, 2019). In doing so, the three types of contrast become the parameters or axes for interpolation. The single character (e) in the Noordzij Cube does not show the impact of the axes on other letterforms and anatomies; for instance, when considering (e) in Venetian and Old Style typefaces, the characteristics of a sloped bar or beak does not appear and thus an all-inclusive typeface would require further axes to fulfil more characteristics such as these.

For Font Variations to successfully expand Gerrit Noordzij's Stroke theory, the correct mapping of axes will need to be accomplished and the geometries of the master outlines must be relateable. A maximum stress of 21° reflects the calligraphic hand of humanist typefaces with a resting point (and minimum value) of no stress (0°) and allows for the selection of contrast by translation. The second axes to be derived is that of contrast by expansion, whereby a maximum contrast of 1:11 decreases to 9:11 for a monolinear typeface. Four master outlines create the bounds of this design space, allowing users to flexibly decide the amount of stress and contrast whose values reflect historical interludes. The affixing serifs to these existing masters allows for a serif axes to increase the breadth of the design space and emulate further style classes. The resulting typeface (*Figure 66*) is comprised of 8 masters at axes poles that can be further expanded to include more design features. The outlines lack details observed when generating style specific instances; however, creating the design space by fundamental axes greatly improves interpolation, and increases the fluidity of the design space which allows for more control when navigating the design space.

Figure 66. Variable Font with Sans-Serif (left page) and Serif (right page)
0° - 20° stress (top–bottom)
low-high contrast (left–right).



Stress 0, Contrast 100, Serf 1

abcdefghijklmnopqrstuvwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ

EOha

EOha

EOha

EOha

Stress 0, Contrast 0, Serf 1

abcdefghijklmnopqrstuvwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ

EOha

EOha

Stress 20, Contrast 100, Serf 1

abcdefghijklmnopqrstuvwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ

EOha

EOha

EOha

EOha

Stress 20, Contrast 0, Serf 1

abcdefghijklmnopqrstuvwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ

EOha

9. Conclusion

The release of OpenType 1.8 Font Variations advances industry standard type design technology to typefaces that can be adjusted in real time by an end user, providing the possibility to create unique instances as per their requirements. By utilising these capabilities, the concept of a typeface that is applicable to all contexts can evolve from previous ideologies which shed excess or are aesthetically neutril, and instead expand the style(s) of a single typeface. The extent of style variation in OpenType format has yet to be fully realised and has been investigated.

The pinnacle outcome of an all-inclusive design space in OpenType 1.8 Font Variations would be a means to store and access *all* existing typefaces. This would replace current typeface libraries and be unanimous in use due to the accessibility of the technology and by allowing users to determine intended typefaces. Researching if OpenType 1.8 Font Variations can be the means to create a universal typeface remains inconclusive or otherwise not possible. The sample of 24 typefaces in the study show great variety in design, even when comparing those within the same style classification. It requires that changes be possible in minute detail within each individual character, perhaps by controlling individual nodes and control points and simply not harmonious with Font Variations. A large volume of typefaces can be hosted by a single file by including their outlines as separate instances, but would need alteration to become compatible for interpolation and would lack intuitive axes.

Focusing on specific typefaces not only reduces the volume of data to a managable state, but also increases possible relationships within a design space to answer the research question of whether a universal typeface is achievable by reducing the scope to historically significant styles. The methods used have resulted in a successful inclusion of historical styles within a design space and axes that retrieve each instance. By segregating the data using the Vox classification system typefaces are not only similarly grouped, but reflect changes in type design in a largely historical manner. Although the Vox system is unable to define all typefaces, the majority can be categorised and archetypes of each style classification have been created as master outlines. The relatable geometries of these outlines make them technically compatible, however, the manner in which they are arranged in a design space and linked by axes was found to be important than the outlines themselves. The most comprehensive scenario found was arranging the outlines across two axes that are (1) chronological by serifs, and (2) sans-serifs arranged by similarly designed typefaces of axis (1); however, this provides limited control across outlines.

The interactivity of master outlines by axes increase the potential of a design space. To answer the research question of how axes and masters can be used to frame a design space resulted in a style-fluid variable fon. Axes were created based on the stroke theory of Gerrit Noordzij. Stress and contrast were used as the primary axes, theoretically able to follow the evolution of type design. Data from the investigation was appropriated for minimum and maximum axes values of contrast and stress and letterforms were created by averaging the culmination of all data (for use with vertical metrics, stroke widths, etc). The literature review identified the design of typefaces by component parts, particularly significant to typefaces created digitally. The practical project was constructed in this manner to facilitate rapid and aesthetically consistent master outlines using 43 shared components. The masters for stress and contrast doubled for the inclusion of a serif axes resulting in a total of 8 masters in a Multiple Masters arrangement (interpolated from corners). The volume of the design space can be expanded by including further axes identified in the data such as Roman–modern proportions, or otherwise by common axes observed in other variable typefaces such as weight, width, or optical size. Investigating how axes influence shapes more closely is a basis to increase the typefaces' possibilities; for instance, the inclusion of a PANOSE 2.0 serif system.

This study has investigated how to approach a universal typeface by using OpenType 1.8 Font Variations and has concluded that although the appearance of a (or multiple) specific typeface(s) can be achieved, the axes of control are of utmost importance. The resulting typeface has been developed which does not mimic specific style classifications or typefaces in favour of a more flexible design space which can be easily expanded to access more design choices. While this may modify the opinion of a universal typeface as an ideal or reduced static instance into an adaptable typeface, encompassing the entirity of existing typefaces remains impossible or is still an undertaking.

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12. Annex 1

Typefaces for Comparison

12.1. Humanist Typefaces

12.1.1. Adobe Jenson Pro

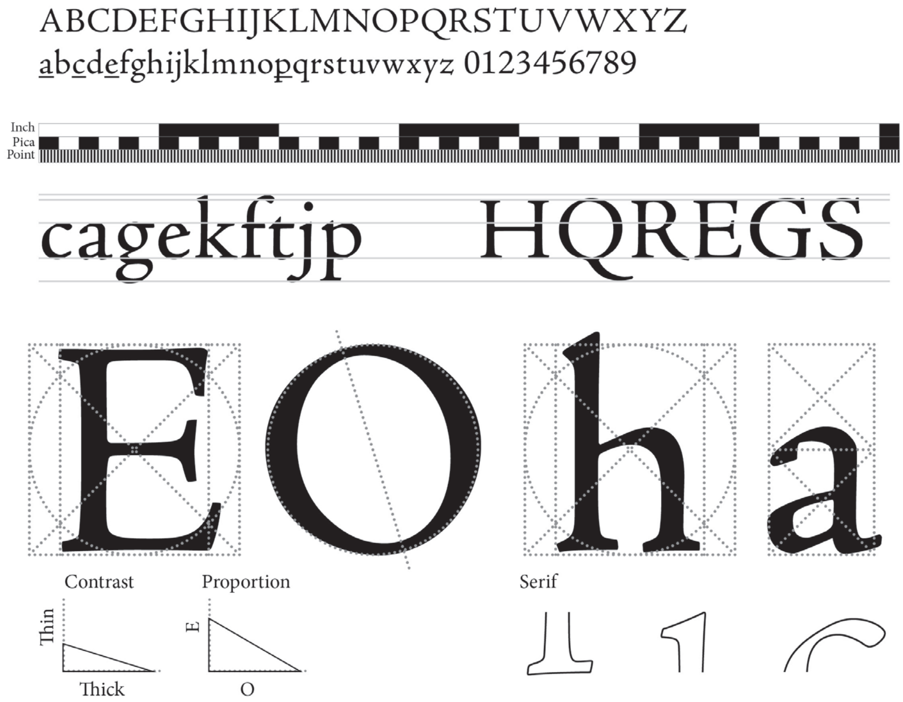

Figure 67. Adobe Jenson Pro [Nicolas Jenson (1470) | Robert Slimbach (Adobe, 1996)]

Nicolas Jenson appears to be the start of a type design revolution revolved around the simplicity of the Roman letterforms with his first publication in Venice Eusebius (1470), and is a frequently reproduced typeface as a result. Adobe Jenson Pro by Robert Slimbach is described as the most accurate rendition, with some modernisation and expansion (Shaw, 2017). The typeface is based on a specific size for texts which enforces the optical sizes of the remainder of the study.

Proportion

8:10. Similarly sized (E) and (O) to an almost entirely geometric (O).

Line Height

Low x-height with an ascender only slightly higher than the Cap-height.

Idiosyncrasies

(e) has an angled crossbar which is not uncommon of this style, but with a very pronounced beak in this instance. The aperture is very large in (a), (c) and (e), the bowl in (a) meets the stem at around half its entire length.

Stress

17°.

Contrast

3:10. High contrast.

Stroke

1:8. The stroke is light and modulated.

Serifs/Terminals

Serifs are asymmetric, with varying amounts of bracketing depending on the stroke direction (most pronounced in the descender of (p). Terminals are slightly rounded, yet dependent on path of the heartline, such as that of (a) and final of (c).

12.1.2. Marco (Centaur)

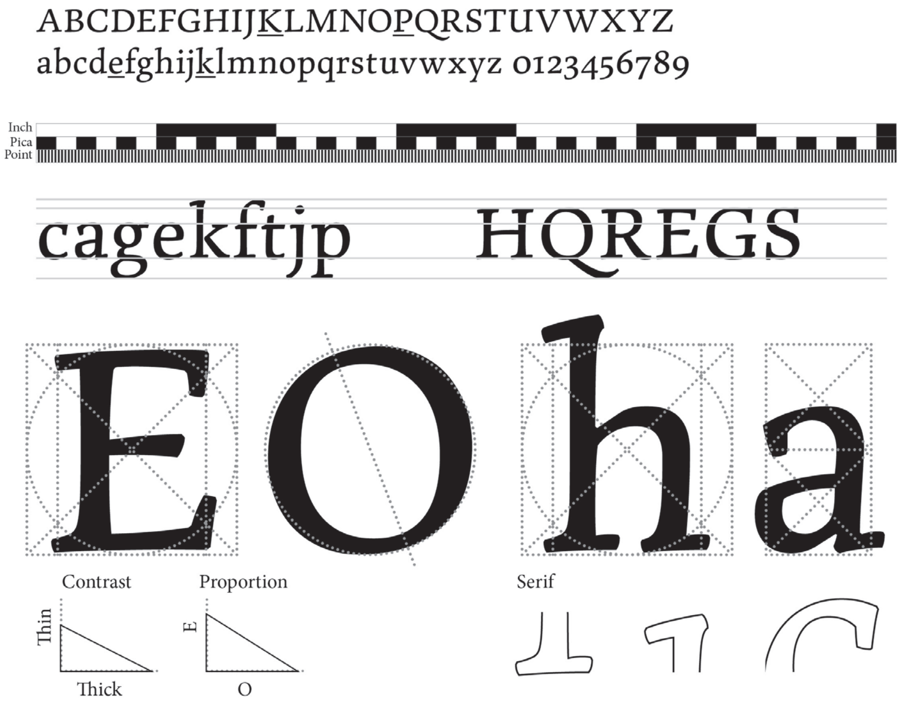

Figure 68. Marco [Jenson (1470) | Bruce Rogers (1914) | Monotype (1929) | Toshi Omagari (Type Together, 2015)]

Marco is based on calligraphic brush stroke, revived by Toshi Omagari in 2015 (Heller, 2016) from 8-pt size and developed by Monotype in an attempt *"to digitally restore how Centaur was supposed to look"* (Omagari, n.d.). The initial Bruce Rogers (1914) designs were based on broad-pen strokes traced over enlarged images of Jenson's Roman letter of 1470, and it is these letterforms first used in a translation of Maurice Guerin's *The Centaur* (The Monotype Corporation Limited, 1933) which Omagari has revived for smaller print.

Proportion

6:10. (E) is of a similar width to (O), which can be attributed to the shape of (O) sitting well within a geometric circle.

Line Height

At first impression there is a tall x-height, however this can be attributed to the low cap-height which sits relatively low compared to the ascender-height.

Idiosyncrasies

(O) has slightly more curve tension to other typefaces. (P), (K) and (k) have strokes (bowl and diagonals respectively) which do not meet their closest stems. Apertures are open, yet (e) has a large eye. (E) has a top arm which is not parallel to the baseline.

Stress

21°.

Contrast

5:10. Peculiarly low contrast for a typeface which also has stress.

Stroke

1:7. A heavy, modulated stroke with some stems slightly skewed (as seen in (h)). (h), (n) and (m) demonstrate calligraphic influence. Shoulders join stems with almost linear strokes,

Serifs/Terminals

Serifs are asymmetrical mixed with bracketing and unbracketed serifs on the same stroke. The central arm of (E) does not have a serif, which is only later seen in Slab-Serif styles. Terminals of (a) and (c) have a pronounced end-of-stroke.

12.1.3. Neacademia

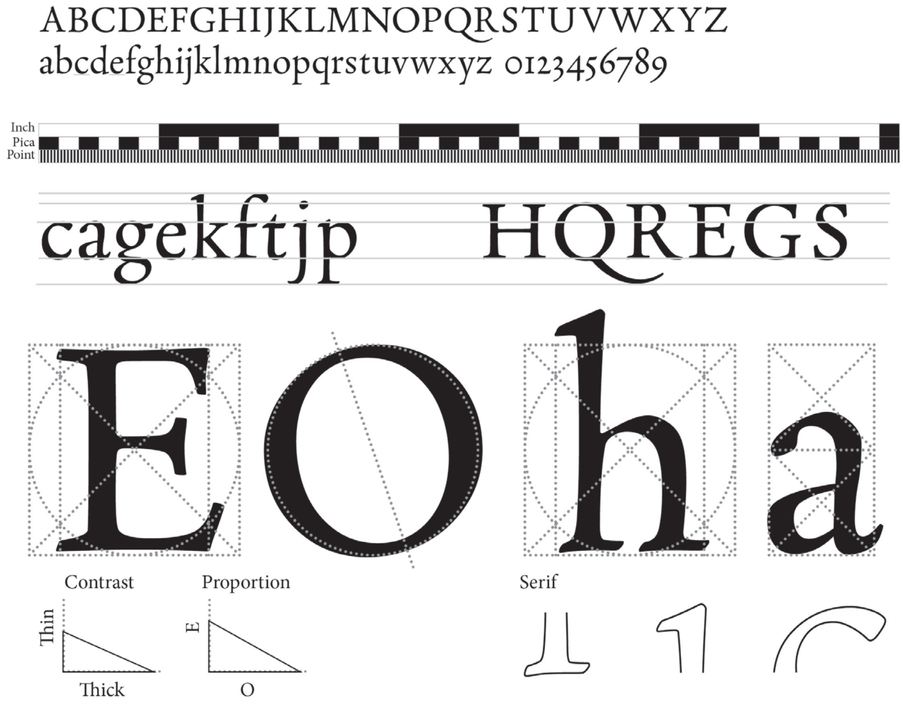

Figure 69. Neacademia [Francesco Griffo (Aldus Manutius, 1495) | Sergei Egerov (Rosetta, 2012)]

Neacademia (2012) by Sergei Egerov is a compilation of Francesco Griffo's Roman uprights (he is also credited with the appearance of the italic form while working for Aldus Manutius). Neacademia (2012) is based on prints of different books which sets it apart from more traditional revivals; providing alternate letter versions and optical sizes.

Proportion

6:10. Narrow (E) and wide (O).

Line Height

A low cap-height exaggerates the x-height with ascenders a good deal higher. Descenders some of the longest in the study.

Stress

19°. High stress.

Contrast

4:10. Medium contrast.

Stroke

1:7. Stroke is heavily modulated and skewed, most visible in (a).

Serifs/Terminals

The finals on (c) and (e) are lifted, compacting the regular stroke direction. Serifs are asymmetrical with differing levels of bracketing on opposite sides of the stroke. The minuscule top serif has a very pronounced flag, yet with soft edges. There is a slight degree of cupping, more evident on vertical serifs.

12.2. Old-Style Typefaces

12.2.1. Garamond Premier Pro

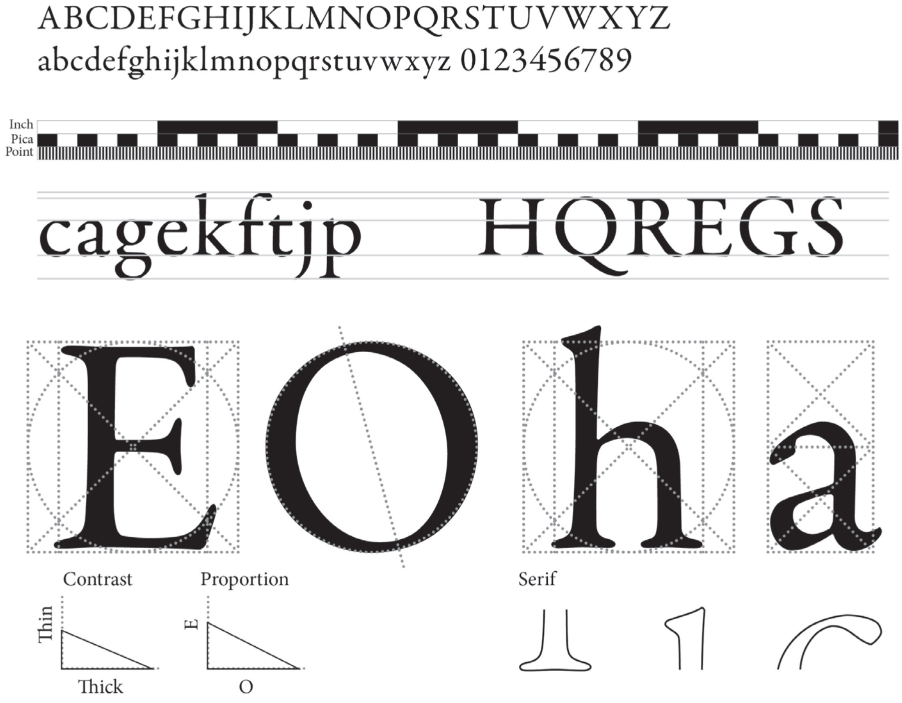

Figure 70. Garamond Premier Pro [Claude Garamont (Gros Canon, 1549) | Robert Slimbach (Adobe, 2006)]

There is an abundance of typefaces named after Garamond or created in the same image; in part because the misidentification of Jean Jannon's typefaces. While not the first Roman letterforms to be cut in France, Garamond deviated from those styles heavily based on Jenson and Griffo. Bringhurst (1997) notes that the oldest Roman punches and matrices that exist are those of Claude Garamond (c.1530), and describes his works as being clearly printed. Robert Slimbach initially designed Adobe Garamond (1989) on a single size Parangon (1957). He revisited the typeface with input from 5 separate sizes, recreating the typeface in Garamond Premier Pro (Shaw, 2012).

Proportion

5:10. The (E) to (O) proportion is very pronounced, with the outer stroke of (O) only slightly larger than a geometric circle.

Line Height

The line heights of Garamond are typically smaller than other Humanist Sans-Serifs and equally so when compared to the entire dataset.

Idiosyncrasies

The ear in (g) is unusually flat and without ornamentation. The bowl in (a) is meets the stem at a larger angle, more typical of Humanist styles.

Stress

15°. The highest of Old-Styles.

Contrast

4:10. Medium contrast.

Stroke

1:8. Modulated stroke. The stem in (h) can be seen slightly skewed. The shoulders of (h) and (a) continue to have curves influenced by a broad nib.

Serifs/Terminals

Bottom serifs are slightly cupped and lack definition at the ends – neither squared nor pointed and are slightly asymmetrical, often reflected when more than one stem in a character exists. Top serif minuscule stems are also slightly cupped and the upper serif of (l) demonstrates a change in curve direction while rising. Terminals of (a) and (c) influenced by a broad nib.

12.2.2. Adobe Caslon Pro

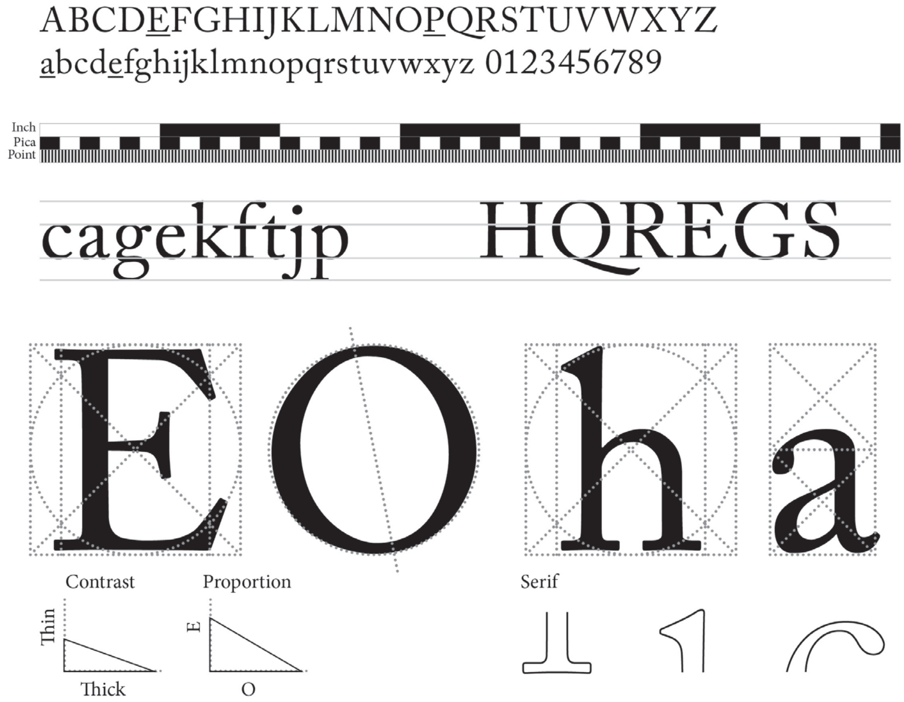

Figure 71. Adobe Caslon Pro [William Caslon (c.1730-1760) | Carol Twombly (Adobe, 1991)]

William Caslon was at the forefront of bolstering the printing industry in England employed to wane away from imported Dutch type, and as such his style was closely reflected by them. The revivals by Carol Twombly and Matthew Carter take similar approaches in designing from several sizes, yet differ in the size model; Carol Twombly's Adobe Caslon Pro (1991), based upon smaller sizes than those of Big Caslon (1994) (whose proportions are akin to display type).

Proportion

6:10. (E) is relatively large compared to (O), which is notably narrower than a geometric circle, with smaller overshoots than usual.

Line Height

The x-height is relatively large. Ascenders are only a marginally taller than the cap-height and could easily be mistaken as the same level.

Idiosyncrasies

The shoulder of (a) protrudes further than its bowl, which meets the stem at a steep angle at both intersections; this makes for a very large aperture and yet a well sized counter. (e) suffers from a far smaller counter at the same aperture. The bowl of (P) is the only instance where it meets the stem within the Old-Style examples.

Stress

11°.

Contrast

4:10. The contrast is moderate when viewing (O), yet increases when considering the bars in (E), (F) and (H), as well as junctions of shoulders and stems.

Stroke

1:8. The stroke is unmodulated. Note the mixed bracketing of the arms in (E), reminiscent of Roman Capitalis.

Serifs/Terminals

Serifs are symmetrical with even bracketing and well pronounced angles at the endpoints. The upper serif of (l) has a flat angle and meets the bracketing with an edge as opposed to an angle. The terminals of (c) and (a) possess the same aesthetic with rounded finals. Majuscule terminals have a large spur.

12.2.3. Renard No.1

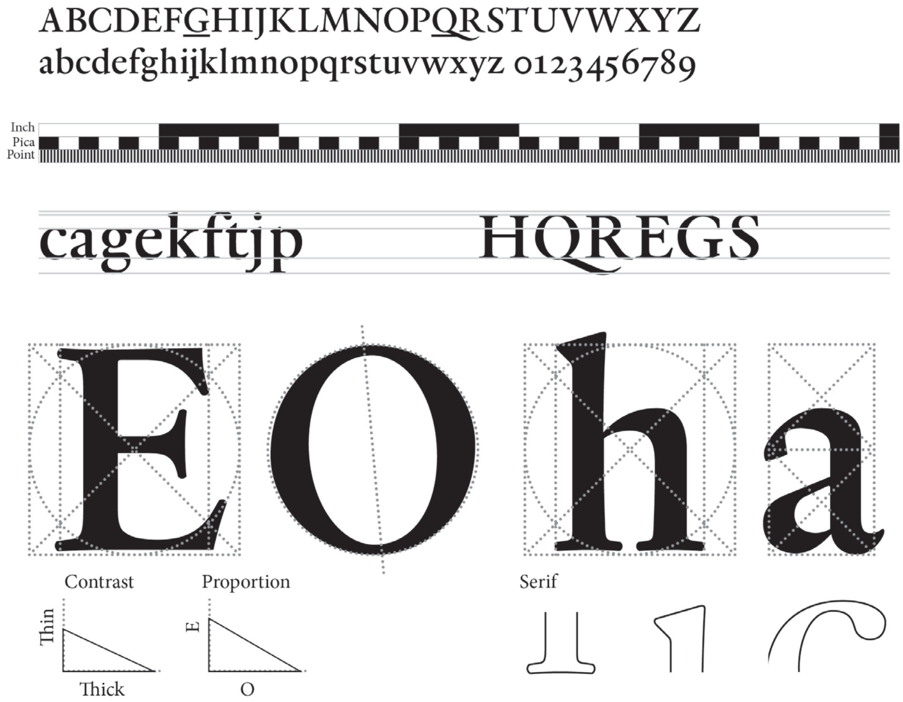

Figure 72. Renard No 1 [Hendrik van den Keere (2 Line Canon Roman, 1570) | Fred Smeijers (TEFF, 1998)]

Hendrik van den Keere is described as the best punch-cutter of the Netherlands during a period of transition of printing superiority from France to the Netherlands. Fred Smeijers and Frank Blokland describe his typefaces being heavily influenced by Garamont, yet *"the only Garamond which can rightfully claim to be* Flemish*, not only because of its roots, but certainly due to its almost Breughelian features"* (Design History, 2011). Smeijer's revival from a 2-line Canon Roman has more interpretation in capitals while staying true to the lower case; Renard No1 (1998) being closest to the original van den Keere Roman, with Renard No2 and No3 in lighter variations (Shaw, 2012).

Proportion

6:10. Proportion of (E) to (O) is much the same as Caslon, however, the elongated central arm of (E) makes it appear narrower. (O) is slightly narrower than a geometric circle.

Line Height

The x-height is the largest within the Old-Styles, and while the ascender-height is highest, the descender is the lowest and cap-height is relatively low.

Idiosyncrasies

The swash of (Q) is particularly elongated, and must be assumed that this would only exist with limited ligatures such as (Qu). The (G) has an almost exaggerated chin.

Stress

10°.

Contrast

5:10. Medium to low contrast.

Stroke

1:6. Strokes are unmodulated and upright with considerable weight. Strokes join stems at a point in contrast to a continuation of the stroke into the stem.

Serifs/Terminals

Serifs have cupping and almost entirely symmetrical. Upper-serifs are almost large wedges being lightly inclined (reflecting the stress). Terminals are mixed between those rounded (c), (f), (r), and angled/abrupt (a), and (j) (whose turn has a lot of calligraphic influence).

12.3. Transitional Typefaces

12.3.1. Romain BP

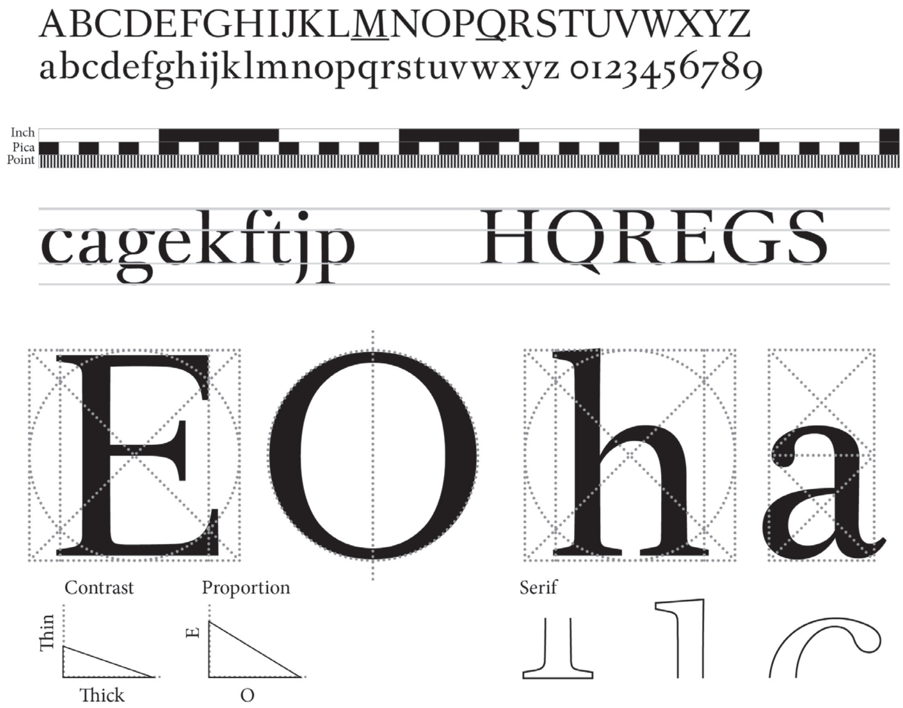

Figure 73. Romain BP [Philippe Grandjean (1702) | Ian Party (BP Type Foundry, 2007)]

Designed by mathematics yet influenced by the engravings of Philippe Grandjean, Romain du Roi revival Romain BP (2007) by Ian Party continues the typefaces' evolution further from the initial mathematical concept in the name of functionality. Romain du Roi took 50 years to complete between 1695 and 1745, where over 20 sizes were created; in a drastic narrowing of optical sizes, Romain BP comes in Roman and Text sizes which vary in contrasts.

Proportion

6:10. (E) is relatively large compared to (O) which is almost entirely geometrically circular, deviating only by curve tension.

Line Height

Ascenders are very slightly larger than cap-heights and generally appear the same level. The x-height is average.

Idiosyncrasies

The tail of (Q) has very little decoration and has a very small profile. The verticals of (M) are not vertical.

Stress

0°.

Contrast

3:10. Medium High contrast.

Stroke

1:7. Unmodulated, slight tapering at the upper serif of (l) stem.

Serifs/Terminals

Serifs are almost entirely symmetrical with straight sides and unbracketed. The upper serif has a very low pitch and thin profile. Terminals are rounded, and the turn of (j) ends at a point in contrast to other finals.

12.3.2. Baskerville 10 Pro

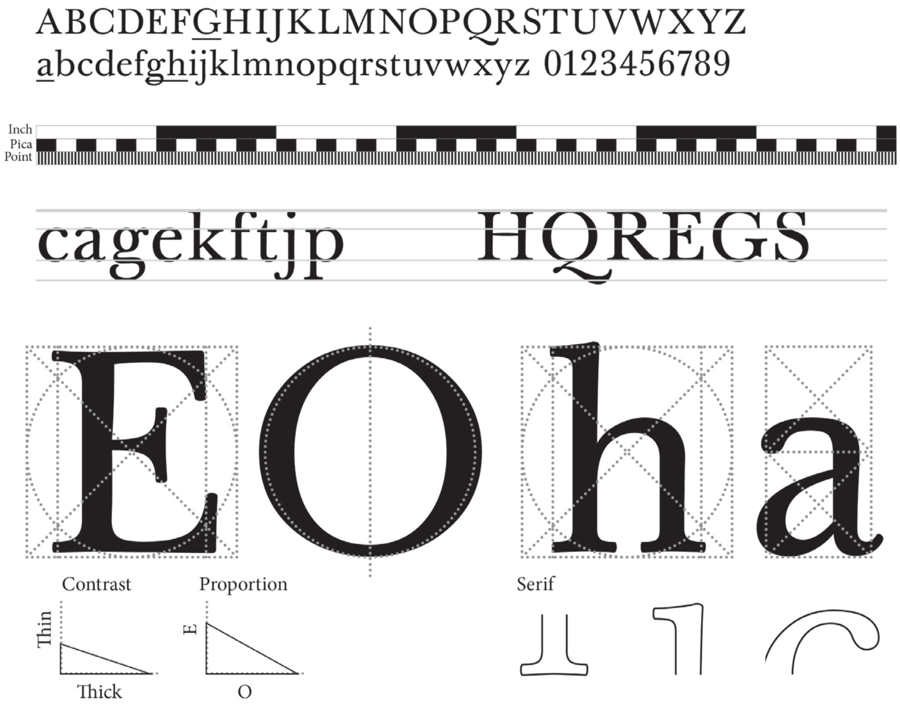

Figure 74. Baskerville 10 Pro [John Baskerville (1757) | František Štorm (Štorm Typefoundry, 2010)]

John Baskerville is not only known for creating a new sub-style of Old-Style type classificatione which deviated from the Dutch styles and works of William Caslon therein, but also for developing paper and ink for use with his printing. František Štorm modelled Baskerville 10 Pro (2010) on Baskerville's Great Primer Roman and is considered the most accurate digital version to date by Paul Shaw (2012).

Proportion

6:10. (E) is slightly narrower than (O) when compared to other Transitional typefaces, due to the large width and large overshoot of (O) when compared to a geometric circle.

Idiosyncrasies

The loop of (g) does not meet the link, an anomaly not shared with the bowl and stem of (P). The aperture in (a) is high due to a shoulder which becomes very shallow. The first demonstration of a (G) with a beard.

Stress

0°.

Contrast

3:10. Medium high contrast.

Stroke

1:7. The stroke is modulated and slight skewing exists as seen in the stem of (h) and shoulder of (a).

Serifs/Terminals

Lower-serifs show cupping to an otherwise calculated and precisely crafted design with rounded corners. This is reflected in the upper serif, with a pitch that is slightly convex. All terminals and turns are rounded and similar in construction.

12.3.3. Eudald News

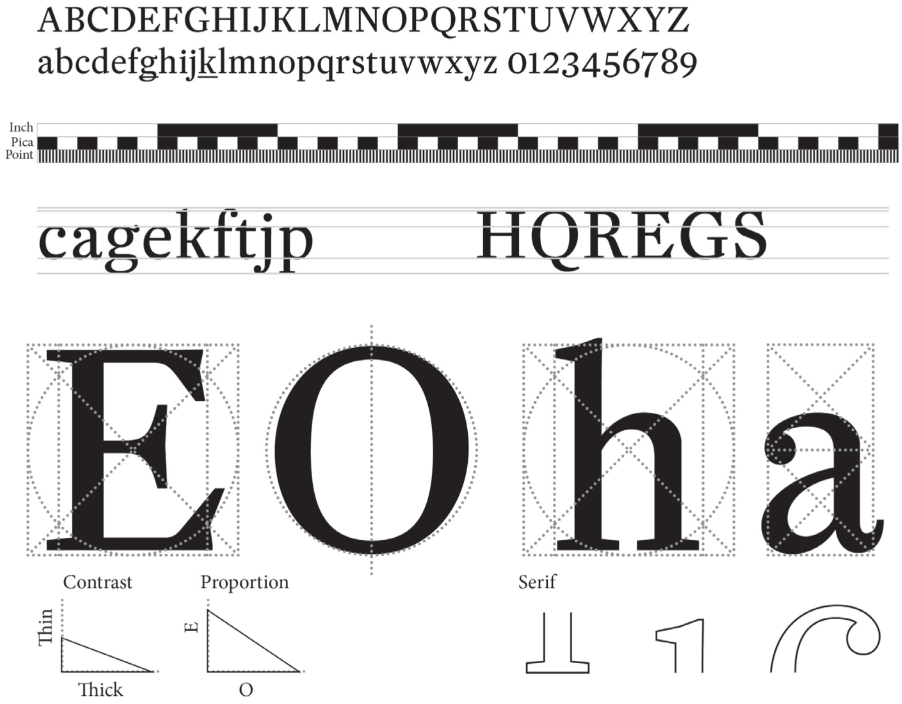

Figure 75. Eudald News [Eudald Pradell (c.1750) | Mário Feliciano (Feliciano Typefoundry, 1998)]

Mário Feliciano designed the revival Eudald News (1998), an interpretation on the works of Eudald Pradell who was a successful punchcutter from Barcelona, Spain (Feliciano Type, 2010). Eudald Pradell was illiterate, in spite of this he was commissioned by King Carlos III to cut typefaces for the Royal printing house in Madrid.

Proportion

7:10. The (E) is slightly larger than other Transitional typefaces, however, the combination with a very narrow (O) expands the proportional difference.

Line Height

Large x-height and relatively small ascender and descender lines. The ascenders become significantly larger than cap-heights when measuring the ascenders from the extremity of the serifs, yet the bracketing between majuscule and minuscule upper-serifs are of similar heights.

Idiosyncrasies

The junction of the (k) to the stem is a stroke in of itself. The ear of (g) is upturned in contrast to other typefaces.

Stress

0°.

Contrast

4:10. The least contrast of the Transitional styles, but more or less equal when viewing the entire study.

Stroke

1:6. Strokes are unmodulated, yet slight tapering can be seen in the upper stem of (h).

Serifs/Terminals

Serifs are squared and bracketed. Where upper and vertical serifs of other typefaces have been convex, cupped or angular, Eudald News (1998) has a strange return in direction of stroke in the initial movement of the serif before changing direction. This is not unique to Eudald news (1998) (likely influenced by Johann Michael Fleischmann), yet rare.

12.4. Modern Typefaces

12.4.1. Ambroise

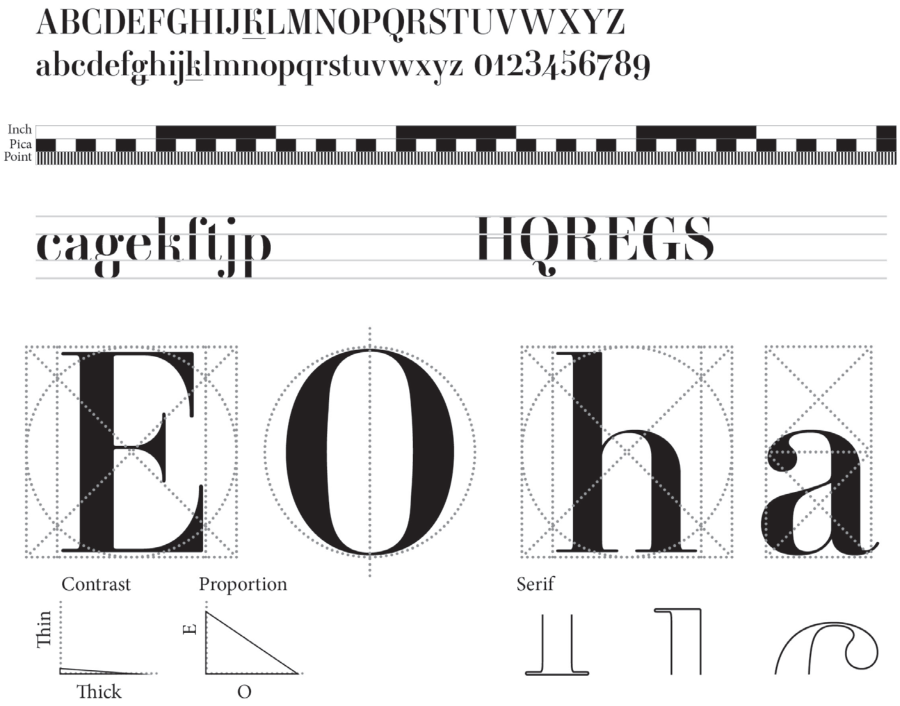

Figure 76. Abroise [Jean-Michael Vibert (Pierre Didot, c.1830) | Jean François Porchez (Typofonderie Porchez, 2001)]

Ambroise (2001) by Jean François Porchez is an insight into the alternative letterforms cut by Jean Michael Vibert for Pierre Didot along with cuts by Pierre's son, Jules Didot. Ambroise (2001) contains contextual alternatives for letters which are otherwise uncharacteristic of Firmin and Pierre's usual letterform design.

Proportion

7:10. Given the condensed nature of the majuscules, the proportions of (E) to (O) are still almost identical to the Modern typefaces.

Line Height

The x-height is the lowest of the Modern typefaces, coupled with the longest ascender and descender. The Ascender and cap-height are exactly equal, unique in the classification.

Idiosyncrasies

There are numerous alternative letterforms: rounded majuscules (A), (E), (N) and minuscules (a), (f), (g), (l), (u), (y). Both letterforms for (g) are unique; the first with a broken loop which can be found in other Didot specimens, and the other (g) being single storey is attributed to the creator Jean François Porchez.

Stress

0°.

Contrast

0:14. The contrast is extreme and far beyond the usual decimal fraction.

Stroke

1:6. The stroke is upright and unmodulated, with clear evidence of contrast by rotation where shoulders meet stems.

Serifs/Terminals

Serifs are symmetrical and lack any sense of depth. The upper-serifs are in the same style as lower-serifs with no protrusions or narrowing of the stem stroke. Ball terminals exist throughout the typeface including the curved hairline diagonal of (k) and (K), an anomaly not evident in other typefaces.

12.4.2. ITC Bodoni Six

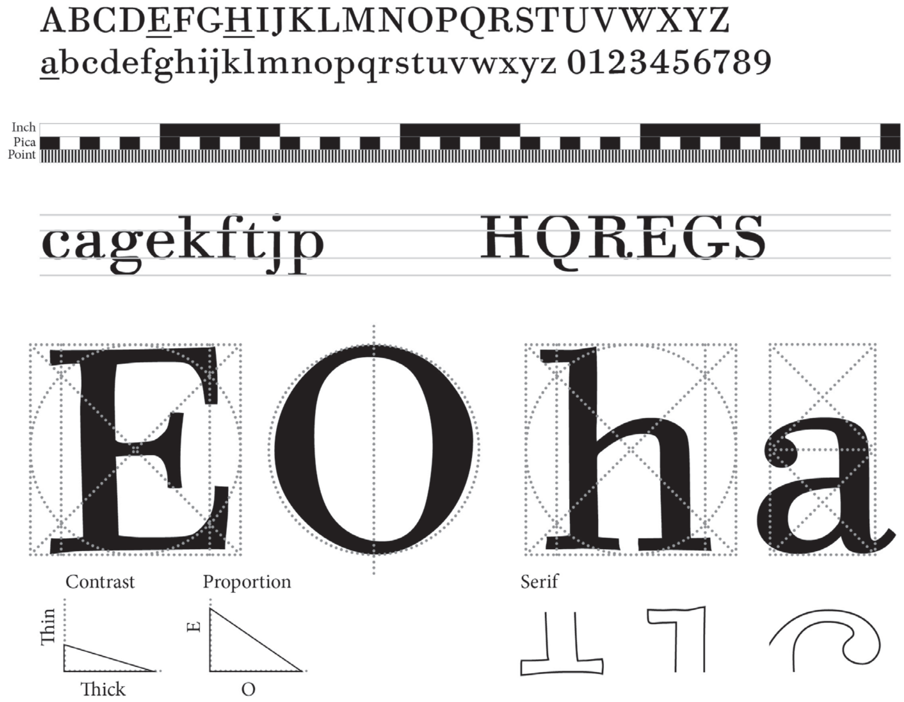

Figure 77. ITC Bodoni Six [Giambattista Bodoni (Papale, 1788) | Jim Parkinson and Summer Stone (ITC, 1994)]

Giambattista Bodoni created a bewildering number of typefaces which varied in design influence between Fournier and Firimin Didot, encouraging a large range of digital revivals as a result. ITC Bodoni Six (1994) by Jim Parkinson and Summer Stone are based on smaller designs (size 6 point) when compared to ITC Bodoni Seventy-Two (1994) by Jim Parkinson created from the largest size available; Summer Stone then interpolated between these extremes to create ITC Bodoni Twelve.

Proportion

7:10. The proportion (E) to (O) are similarly sized as with other Modern typefaces.

Line Height

Ascender and cap-heights vary, yet by an amount which is insignificant and can be assumed equal. Descenders are slightly shorter than other hairline Modern types.

Stress

0°.

Contrast

3:10. Contrast is high, yet far less extreme than what is normally associated with Moderns crafted by Giammbatista Bodoni or Firmin Didot (in a digital environment), this is due to the small cut-size of ITC Bodoni Six (1994).

Stroke

1:6. The stroke almost appears modulated, but may be recovering inaccuracies of the type specimen. What is evident are slight left skewing from the vertical as seen in the stems of (a) and majuscules, the only instance of this in the study.

Serifs/Terminals

There exist many inconsistencies between serifs, such as cupping evident in the lower-serifs of (l) and asymmetrical lower-serifs of (h). the upper serif of (h) shows a protrusion of the stem with a slight pitch which joins with the flat serif. Ball terminals end turns and are even present on the leg of (R).

12.4.3. Miller Text

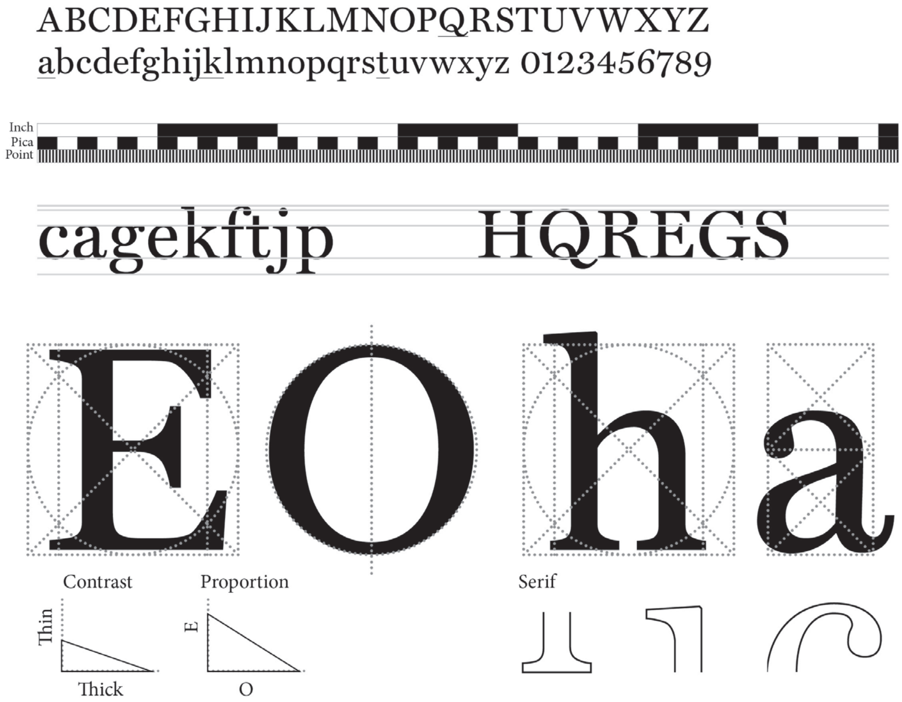

Figure 78. Miller Text [Richard Austin (Alexander Wilson, 1810) – Matthew Carter (Font Bureau, 1997)]

Paul Shaw categorises the work of Richard Austin as neoclassical, whose style was in actuality a response to the fragile nature of Modern styles leading to a sub-classification called Scotch Roman. Matthew Carter designed Miller with reference to Richard Austin's principles.

Proportion

6:10. The proportion of (E) is slightly more narrow than other Modern typefaces, due to an (O) only a fraction narrower than a geometric circle.

Line Height

Miller has a tall x-height, or possibly a low cap-height which is at a significantly lower level than the ascender-height. Descenders are unusually short.

Idiosyncrasies

The minuscule (k) has a curved leg, the (t) a flat top and the swash of (Q) is ornate in a fashion which recurs in Slab-Serifs and Fat Faces. The (a) has a bottom terminal which returns to the vertical.

Stress

0°.

Contrast

3:10. The contrast is high, yet on the lower side of Modern typefaces.

Stroke

1:6. Strokes are upright and unmodulated.

Serifs/Terminals

Serifs are uncharacteristically unbracketed when compared to Modern typefaces. The lower-serifs are in fact quite wide, yet appear less so due to their depth. The upper serif has a shallow pitch. Terminals on (a) and (c) are rounded, yet the turns of (f) and (j) end with ball terminals.

12.5. Slab-Serif Typefaces

12.5.1. OL Egiziano

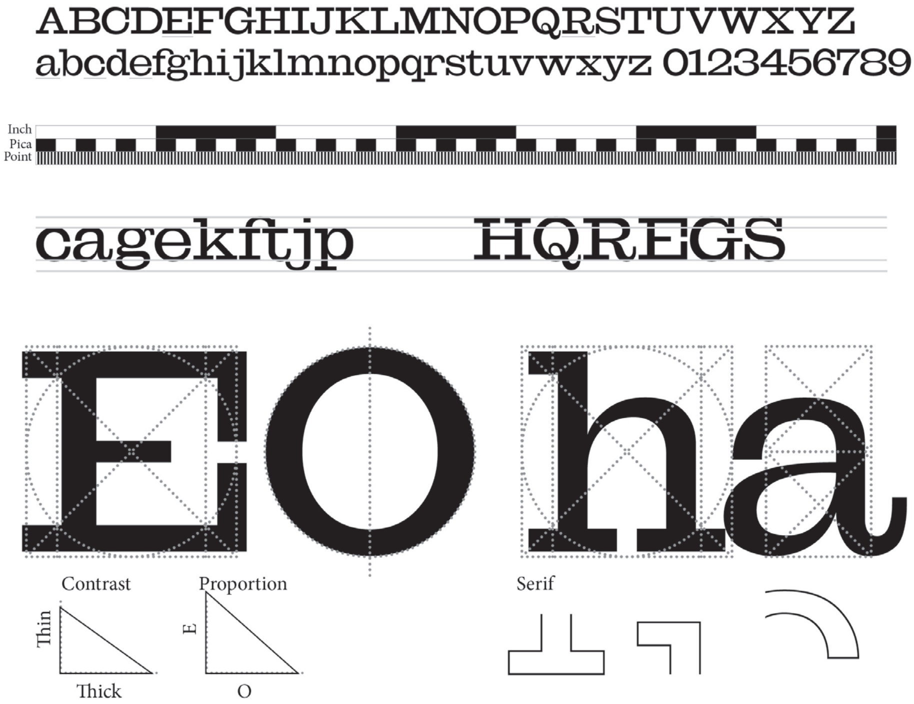

Figure 79. OL Egiziano [Egiziano Nero (Nebiolo, 1920) | Dennis Oritz-Lopez (OL Fonts, 2003)]

Niebolo Type Foundry released a Slab-Serif in 1920 under a typically Egyptian named series: Egiziano (Shaw, 2017), which was itself electroplated from the Egyptian Antique No.6 by Stephen Shanks, released by Figgins in 1815. As Electroplating creates a nigh on identical copy from which the Oritz-Lopez digital was based; the revival OL Egiziano (2003) becomes a revival of the Corpo 24 size facsimile of Egyptian Antique No.6.

Proportion

9:10. The wide (E) is almost identical in width to (O) which is entirely circular, if not slightly wider. The minuscule are equally wide.

Line Height

Ascenders and cap-height are the same level and only moderately higher than the large x-height. Descenders are shallow when considering the matrix height, however, are in reasonable proportion to the difference in ascender-height to x-height.

Idiosyncrasies

Apertures are almost entirely closed in (a), (c), (e), (C) and peculiarly, (E).

Stress

0°.

Contrast

7:10. Contrast is very low, approaching mono-linear. However, diagonals, and shoulders of the minuscule increase in contrast when intersecting stems.

Stroke

1:6. Stroke is unmodulated and upright.

Serifs/Terminals

Lower-serifs are symmetrical, wide, and with a depth equal to the stroke. Upper strokes are flat. Terminals are squared, ending entirely horizontal, including any turns of both minuscule and majuscule (such as a turn in the leg of (R).

12.5.2. Consort

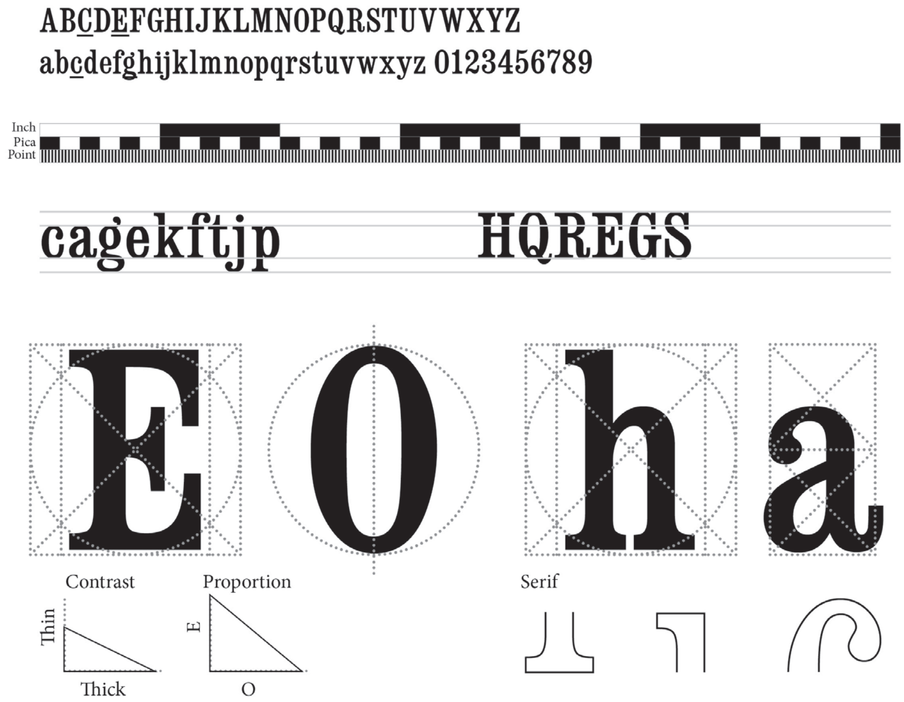

Figure 80. Consort [Robert Besley (Fann Street Foundry, 1845) | Stephenson Blake (c.1950) | Steve Jackaman (International Typefounders Inc., 1994)]

Consort Condensed Bold is a revival of the original 1845 Clarendon created by Robert Besley went on to become its own subclassification of Slab-Serifs – *Clarendons* – unique to Egyptian styles of the time (West, 2022).

Proportion

8:10. While the typeface is exceptionally condensed, the (E) remains wide in comparison to (O).

Line Height

The ascender is slightly higher than the cap-height by an unnoticeable amount. x-height is large, and descender line is shallow.

Idiosyncrasies

The ear of (g) is upturned and ends far above the x-height.

Stress

0°.

Contrast

5:10. The contrast is moderate, in-part disguised by the weight of the strokes and width of letterforms.

Stroke

1:6. The stroke is unmodulated and upright. There is a return to rounded forms within letters such as the lower leg of (E) when meeting the stem and (L) and within the counters of (B) and (D).

Serifs/Terminals

Ball terminals adorn the finals and turns of (a), (c), (j), (f) and (J), where lower terminals are squared to the horizontal in (a), (c), (e), and (C).

12.5.3. Joanna Nova

Figure 81. Joanna Nova [Eric Gill (Monotype, 1931) | Ben Jones (Monotype, 2015)]

Joanna Nova (2015) was a revision by Monotype in sequence to Eric Gill's famous typeface Gill Sans Nova (1931). Undertaken by Ben Jones in 2015, Joanna (2015) is a contrast to many Slab-Serifs by its Humanist letterforms and light weight.

Proportion

5:10. There is a return to Roman proportions, with (E) less than half the width of (O) which is slightly wider than a geometric circle. These proportions are charismatic of typefaces by Eric Gill.

Line Height

Ascenders and descenders are elongated. The low cap-height exaggerates what is a low x-height.

Stress

0°.

Contrast

5:10. Contrast is moderate, yet due to the width in (O) the transition between thick and thin reduces the effect of the contrast.

Stroke

1:9. Stroke is unmodulated, with some calligraphic influences such as the weight towards the beak of (e).

Serifs/Terminals

Terminals are squared at the vertical and spurs in the terminal of (c). The turn of (j) ends square to the vertical, yet (f) has a larger stroke at its terminal.

12.6. Humanist Sans-Serif Typefaces

12.6.1. Gill Sans Nova

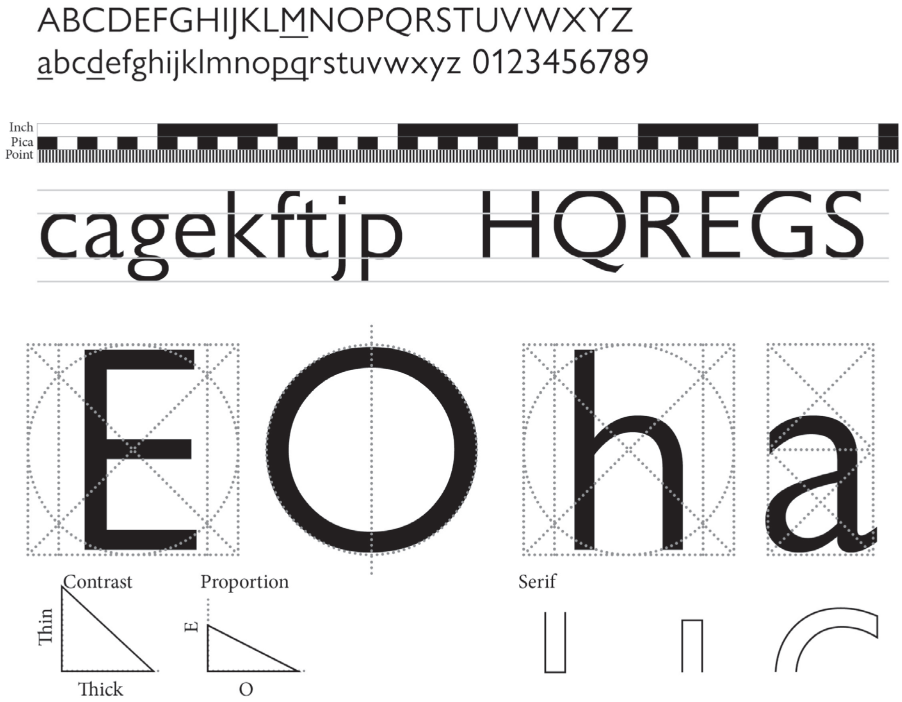

Figure 82. Gill Sans Nova [Eric Gill (Monotype, 1928) | George Ryan (Monotype, 2015)]

Gill Sans designed in 1928 is one of a few Humanist Sans-Serif typefaces which predate its subclassification, only included after the coin of phrase. Gill Sans Nova is a 2015 revision of the existing Monotype type family which had haphazardly expanded in weights with little to no input from original creator Eric Gill. The revision concludes as a compromise between the original and later renditions, with a mixture of original, accumulated, and letters harmonised by George Ryan.

Proportion

5:10. The width of (E) is approximately half of (O), which is wider than a geometric circle, particularly when noticing the small overshoots.

Line Height

Ascender and cap-heights are equal, uncharacteristic of most Humanist, Old-Style, and Transitional typefaces. The x-height and descender line are lower in value, however, can be considered in proportion given the small matrix size.

Idiosyncrasies

(d), (p) and (q) have bowls which meet perpendicular to the stem, a manner which is separated from calligraphic principles. The (M) has a crotch which ends at the x-height and not the baseline.

Stress

0°.

Contrast

9:10. The typeface is almost mono-linear, and reverse contrast is seen in the shoulder of (a) which has a heavy stroke throughout.

Stroke

1:9. Unmodulated and upright.

Serifs/Terminals

Terminals all end at a vertical angle.

12.6.2. Optima Nova

Figure 83. Optima Nova [Hermann Zapf (Stempel, 1958) – Hermann Zapf and Akira Kobayashi (Linotype, 2002)]

Designed by Hermann Zapf in 1958, Optima set the definition of Humanist Sans-Serif typefaces *"as it appeared to be neither a serifed face nor a Grotesque in the 19th century manner",* but as a serif-less Roman (Shaw, 2017). Optima Nova, the 2002 redesign by Hermann Zapf and Akira Kobayashi holds true to the original design, based on the inscriptions found on the floor tombs in Santa Croce by Zapf in 1950.

Proportion

5:10. (E) is less than half of (O). (O) is significantly wider than a geometric circle with high curve tension (amounting to a *squarer* ellipse).

Line Height

Optima has an extremely high ascender-height and equally low descender, making a high x-height balanced halfway in the matrix.

Idiosyncrasies

Due to the modulation and turns, characters such as (f) show a narrowness which would be found in early calligraphic forms.

Stress

0°.

Contrast

4:10. Very high contrast.

Stroke

1:8. Stroke is modulated and large amounts of cupping are found at their ends.

Serifs/Terminals

Sans-Serif. While terminals can be angular (with the exception of (a)), finals are squared vertically.

12.6.3. Sean Sans/Canola

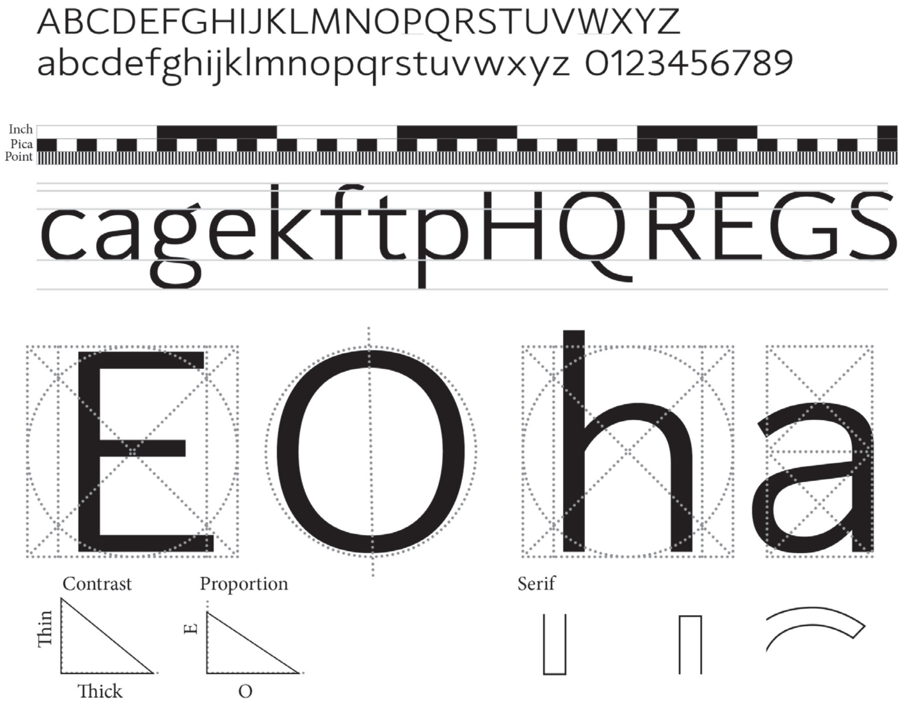

Figure 84. Sean Sans/Canola [Conrad Berner (Egenolff, 1592) | Georg Duffner (2011) | Simon Egli (2014)]

Paul Shaw states that *"the most important aspect of Humanist Sans-Serif type is that they have proportions and an underlying structure based on Old-Style typefaces… whether or not letters have contrasting thin/thick strokes like Optima or Pascal, is not essential"* (Shaw, 2017). Sean Sans (2011) is the only typeface included which is not from Revival Type by (Shaw, 2017) and is included for its proximity to his definition of a Humanist Sans-Serif. Sean Sans (2011) was initially developed as the skeletal form of EB Garamond (2011) for use with METAPOLATOR: *"We took EB Garamond and paired it down to its essential sans, its mono-linear strokes, so Simon named the design Sean. I think that the fundamental forms in Garamond are so familiar to us that by boiling it down, the results are very pleasing"* (Crossland, 2019). EB Garamond created by Georg Duffner in 2011 is a revival of letterforms in the Bernier Specimen, created by Conrad Bernier in 1592 for the Egenolff Print Office, an establishment founded by his father-in-law.

Proportion

7:10. Where other Humanist serifs have been closer to Roman Capitalis, the (E) of Sean Sans (2011) is a little wider, yet remains considerably narrower than the (O) which is itself narrower than a geometric circle with moderate curve tension.

Line Height

The line heights of Sean Sans (2011) match Garamond Premier Pro (2006) with the exception of a greater x-height which must be attributed to either a difference in stroke weight (by which Sean is lighter), or to the design of EB Garamond (2011).

Idiosyncrasies

It is difficult to recognise Garamond in Sean Sans (2011), not only due to the lack of serifs, stress and contrast, but also the width of the letterforms and apertures. Counters appear much larger, and some letterforms such as (W) do not correspond with Old-Style characters. It can only be assumed that the designer has influenced the appearance while simplifying the typeface for use with METAPOLATOR.

Stress

1°.

Contrast

8:10. The typeface may appear mono-linear, however there is a degree of contrast which is in actuality greater than Gill Sans Nova (2015).

Stroke

1:9. Unmodulated and upright.

Serifs/Terminals

Sans-Serif. Terminals end at the same angle, including the ear of (g).

12.7. Grotesk Typefaces

12.7.1. FF Bau

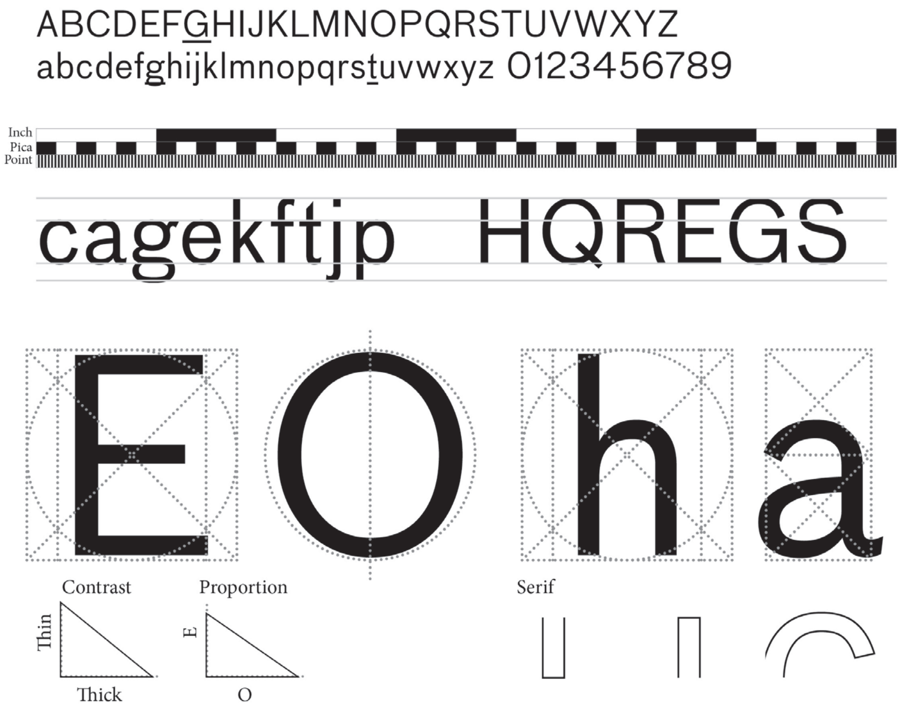

Figure 85. FF Bau [Breite halfbette Grotesk (J.G. Schelter & Geisecke, 1886) | Christian Schwartz (FontShop, 2002)]

Schelter Grotesks created by foundry J.G Schelter & Geisecke (the first appearing in 1886) is an earlier example of a Sans-Serif typeface, which became popular in the Bauhaus movement. As with many German Grotesk typefaces, the origins are not entirely clear, with some speculation to imported matrices from England and America, and yet widespread throughout Germany by the late 19th century, of which J.G. Shelter & Geisecke was a reputable type foundry able to reproduce and resize type. FF Bau (2002) by Christian Schwartz for FontShop with direction from Erik Spiekerman was revived with interests in some peculiarities of Grotesks lost in Neo Grotesks.

Proportion

7:10. (E) is relatively large compared to (O) which is narrower than a geometric circle with the least curve tension of the Grotesks.

Line Height

There is a negligible difference in cap and ascender-heights, only slightly visible when comparing (E) and (h) in a fixed cap-height. The x-height is slightly above average of the entire study, however, remains the lowest of the Grotesks.

Idiosyncrasies

Apertures in Bau are significantly more closed than other Grotesks. The minuscule (g) is double-storey. The end of (t) is cut at a high angle. (G) has a beard. The shoulders of (h), (n) and (m) are notably narrow.

Stress

0°.

Contrast

8:10. Low contrast.

Stroke

1:9. Regular upright stroke.

Serifs/Terminals

Sans-Serif. There exists a turn in the lower terminal of (a).

12.7.2. FF DIN

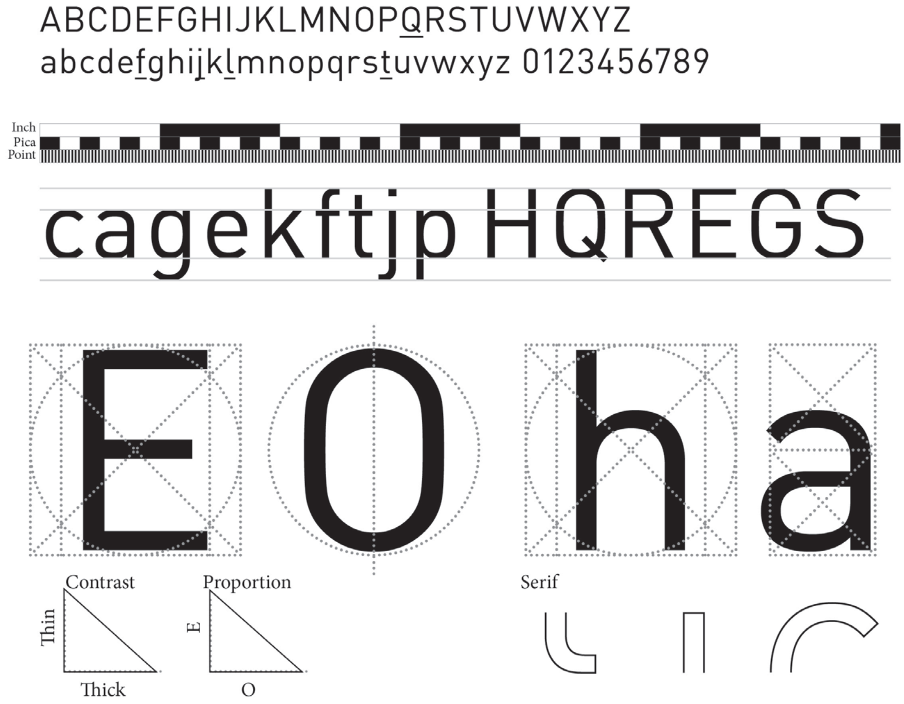

Figure 86. FF DIN [DIN1451 (1936) | Albert-Jan Pool (Fontshop, 1995)]

The concept of the Deutsch Industrie Normen (DIN) typeface is historically significant given its unifying objective and resistance to it by the printing industry. With no single attributed designer, DIN1451 released in 1936 in 3 weights (the condensed of which dating to 1905 Royal Prussian Railway type) is the model which Albert-Jan Pool used as a basis to recreate the style with improved legibility and expanded family for more versatile use, resulting in FF DIN in 1995 (Berry, 2006).

Proportion

9:10. (E) has a similar width to other Grotesks, however the (O) is exceptionally narrow with curve tension so high as to almost create straight vertical strokes.

Line Height

DIN has long descenders, an x-height average to Grotesks, yet the cap-height and ascender-height (which are the same level) are significantly lower.

Idiosyncrasies

The curve tension of the typeface is high, creating a somewhat *squared* design. While the typeface is void of features, the minuscule (l) has a foot. The upper stroke of (t) ends square to horizontal where other typefaces include a pitch.

Stress

0°.

Contrast

9:10. The contrast is extreme low, only surpassed by Gill Sans.

Stroke

1:9. Regular upright stroke.

Serifs/Terminals

Sans-Serif, the terminals follow the same angle with the exception of the tail of (Q) slightly steeper, (G) whose terminal ends square to horizontal and turns of (f) and (j) vertical.

12.7.3. Univers Next

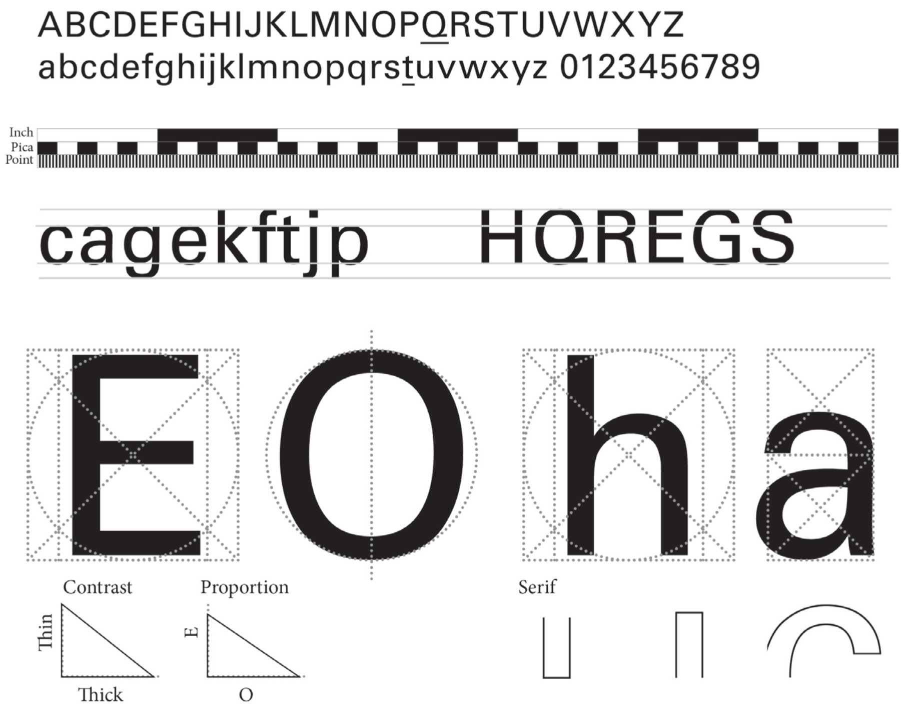

Figure 87. Univers Next [Adrian Frutiger (Deberny & Peignot, 1957) | Adrian Frutiger (Linotype, 1996)]

With a large family of a typeface in mind, Adrian Frutiger designed and released Univers with an entire range of weights and widths in 1957, structuring a naming system based on the periodic table. Frutiger was invited by Linotype in 1996 to revise Univers to a new digital format, given shortcomings in the adaptation from phototype to PostScript 1 format; resulting in Linotype Univers in 1997, a name change in 2010 to Univers Next, and a Variable version in 2019 (Luc Devroye, 2022).

Proportion

7:10. Proportion of (E) to (O) is almost identical to FF Bau (2002) and shares the same width, distinguishable only by a stronger curve tension and stroke weight.

Line Height

The ascender and cap-heights differ by a single point (in an em square of 1000 units). The x-height is the tallest of the Grotesks, and second highest in the study (surpassed by Gotham (2000)). Descender-line is short and equal to FF Bau (2002).

Idiosyncrasies

The arms of (E) are the same length (or with minute differences for the central bar). The tail of (Q) has an entirely different form than other typefaces when considering the strokes starting location and following the baseline.

Stress

0°.

Contrast

8:10. Low contrast.

Stroke

1:7. Regular and upright.

Serifs/Terminals

All stroke ends are squared either vertically or horizontally with the exception of (t) whose upper stroke terminal is angled approximately 45°.

12.8. Geometric Typefaces

12.8.1. Futura ND

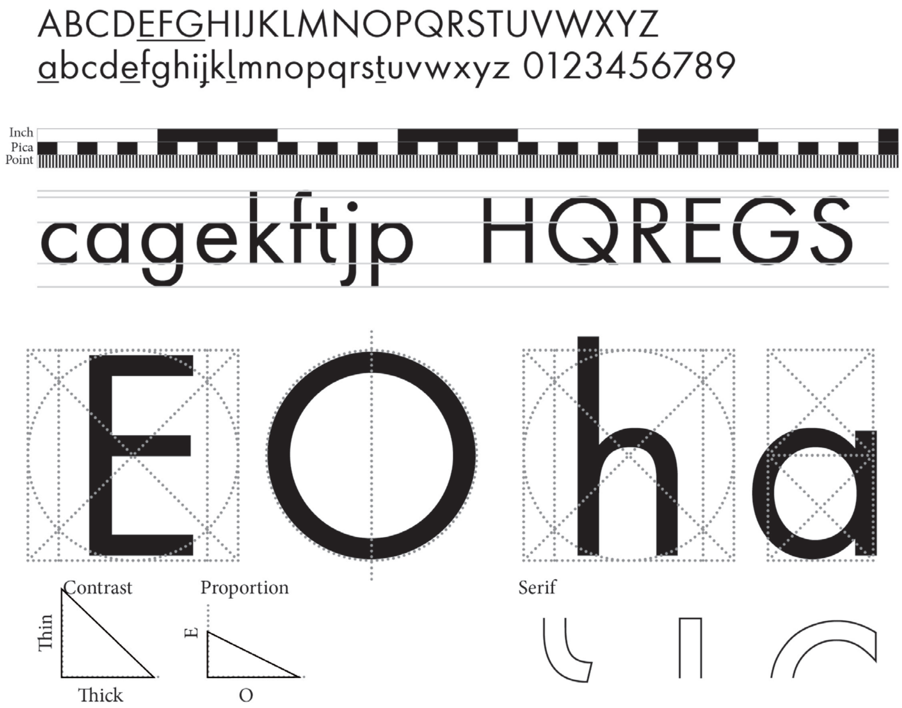

Figure 88. Futura ND [Paul Renner (Bauer, 1927) | Neufville Digital (1999)]

The era of change and experimentation of rational form which resulted in the creation of Futura (1927) by Paul Renner is a juxtapose to those historical methods of achieving an ideal typeface by rational form. Neufville Digital whom are legal successors to Bauer have created a digital version in 1999 which reflect early releases of Futura including some of Paul Renner's alternative characters.

Proportion

5:10. (E) is almost exactly half of (O) which is marginally wider than a geometric circle. Minuscules are generally slightly condensed.

Line Height

Ascender-height is taller than the cap-height. The x-height is low in proportion, particularly when considering a moderate descender.

Idiosyncrasies

Futura retrieves a single storey (a). The bars of (E), (F) and (H) along with the upper bowl of (B), (P) and (R) are positioned close to the x-height.

Stress

0°.

Contrast

1. Contrast is almost non-existent, almost a 45° angle as per the diagram: a 5% variation in strike width.

Stroke

1:9. Regular and unmodulated, with almost no change at the junctions of shoulders and stems.

Serifs/Terminals

No serifs. (l) has a foot. Turns of (f) ends vertically while (j) has a slight incline. The terminals of (c) and (C) are uncharismatic, ending vertically, not unusual in itself, however, (e) and (G) do not follow the same principle.

12.8.2. Semplicatá Pro

Figure 89. Semplicatá Pro [Alessandro Butti (Nebiolo, 1931) | Patrick Griffin (Canada Type, 2011)]

Influenced by the appearance of Futura in Italy, Alessandro Butti created Semplicatá in 1931, which remained popular nationally until the 2010 revival by Patrick Griffin which brought international interest, albeit at the cost of some of proportion changes and alternate characters which distance it from the original.

Proportion

5:10. The (E) is amongst the narrowest in comparison to the (O) which is over double the width, exacerbated with a form which is wider than a geometric circle.

Line Height

A relatively high cap-height is yet significantly lower than the ascender-height. The x-height is slightly below the study average.

Idiosyncrasies

Where bowls in (a), (b), (d), single storey (g), (p), and (q) would normally meet the stem, Semplicatá's letterforms have stems which end at the bowl, and thus the junctions deviate from baseline and mean-line.

Stress

0°.

Contrast

9:10. Low contrast.

Stroke

2:21. Regular and upright with little visible change at junctions of stems and shoulders.

Serifs/Terminals

Terminals are all at angles which vary. This can be seen most in the terminals of (c) when comparing to the turns of (f) and (j).

12.8.3. Gotham

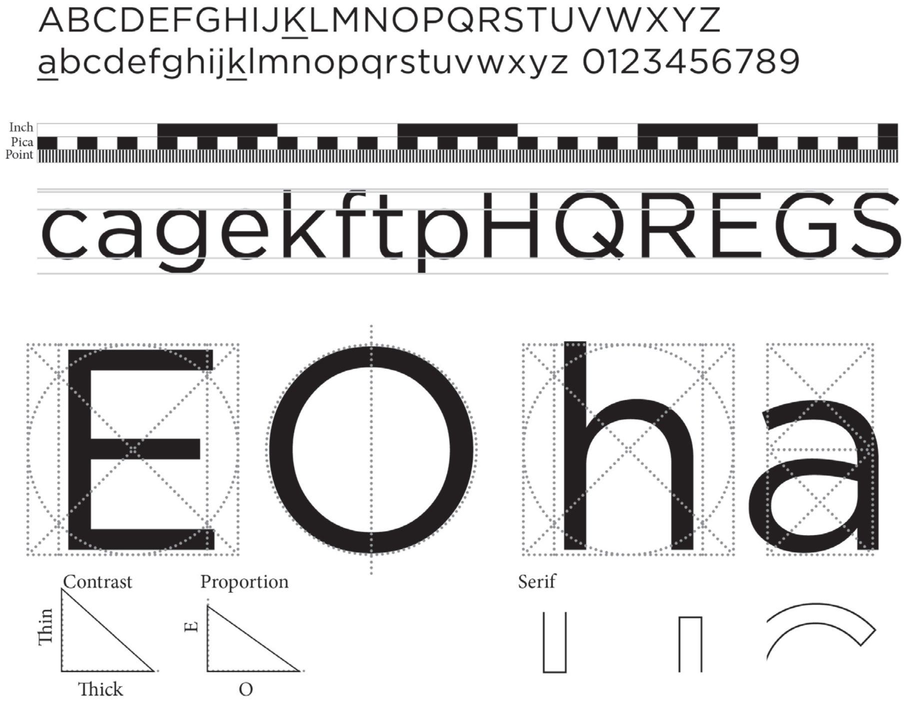

Figure 90. Gotham [New York City Signage (c.1930-1960) | Jonathan Hoefler and Tobias Frere-Jones (Hoefler Type Foundry, 2000)]

Gotham (2000) is designed around signage of public buildings in a period of public spending and following the Art Deco movement. The letterforms which Frere-Jones took inspiration from were exclusively majuscules, and thus the minuscules are entirely by his creation. The typeface is particularly popular in the political arena of the USA, providing an American-born revival of a period of growth (which ignores the popularity of similar letterforms in fascist Italy).

Proportion

7:10. Where other geometric typefaces follow classical proportions, the (E) of Gotham is far wider, more akin to Modern typefaces with an (O) ever so slightly narrower than a geometric circle.

Line Height

The expanded letterwidths disguise an ascender-line which is moderately taller than the cap-height. The x-height is significantly taller than any other typeface within the study and the same applies to the difference in the shallow descender.

Idiosyncrasies

Gotham provides both single and double storey (a). Where other geometric typefaces have diagonals in (k) and (K) which meet the stem, the width of Gotham requires the leg to meet the arm close to its centre point.

Stress

0°.

Contrast

9:10. Extremely low contrast with some narrowing at junctions of stems and shoulders, and particularly evident in junctions of bowls and stems.

Stroke

1:9. Regular upright.

Serifs/Terminals

Sans-Serif. Terminals follow the same or similar angle and allow for wide apertures.

13. Annex 2

Typeface Comparison Data

	Typeface	Em	Stem Width	Modulated	Cap height	Ascender	Mean Line	Descender	Matrix Height	ascender height ratio	cap height ratio	x-height ratio	descender height ratio	Stress	Stem - Cap ratio	E-O	E-O fraction	Contrast	Contrast Fraction	Contrast Vs Stem Width	stem width to 90pt ratio	cap height to 120 ratio
Humanist	**Adobe Jenson**	1000	83	1	649	701	383	-246	895	78/100	73/100	43/100	- 27/100	17	1/8	0.80	8/10	0.31	3/10	25.67	54.22	184.90
	Marco	1000	95	1	638	746	440	-250	888	84/100	72/100	50/100	- 28/100	21	1/7	0.63	6/10	0.51	5/10	48.26	47.37	188.09
	Neacademia	1000	94	1	689	828	458	-316	1005	82/100	69/100	46/100	- 31/100	19	1/7	0.56	6/10	0.44	4/10	41.67	47.87	174.17
average		1000	91		659	758	427	-271	929	82/100	71/100	46/100	- 29/100	19	1/7	0.66	7/10	0.42	4/10	38.10	49.63	182.38
Old Style	**Garamond Premier Pro**	1000	84	1	643	706	390	-257	900	78/100	71/100	43/100	- 29/100	15	1/8	0.51	5/10	0.42	4/10	35.67	53.57	186.63
	Adobe Caslon Pro	1000	93	1	708	723	417	-272	980	74/100	72/100	43/100	- 28/100	11	1/8	0.59	6/10	0.36	4/10	33.42	48.39	169.49
	Renard no 1	1000	117	0	676	734	462	-235	911	81/100	74/100	51/100	- 26/100	10	1/6	0.58	6/10	0.47	5/10	54.53	38.46	177.51
average		1000	98		676	721	423	-255	930	77/100	73/100	45/100	- 27/100	12	1/7	0.56	6/10	0.42	4/10	40.83	45.92	177.88
Transitional	**Romain BP**	1000	107	0	773	786	479	-293	1066	74/100		45/100	- 27/100	0	1/7	0.61	6/10	0.35	3/10	37.00	42.06	155.24
	Baskerville	1000	108	1	707	728	455	-272	979	74/100	72/100	46/100	- 28/100	0	1/7	0.56	6/10	0.33	3/10	36.06	41.67	169.73
	Eudald News	1000	112	0	712	756	476	-224	936	81/100	76/100	51/100	- 24/100	0	1/6	0.67	7/10	0.38	4/10	42.28	40.18	168.54
average		1000	109		731	757	470	-263	994	76/100	74/100	47/100	- 26/100	0	1/7	0.61	6/10	0.35	4/10	38.41	41.28	164.50

Modern	**Didot (excluded)**	1000	100	0	712	721	429	-280	992	73/100	72/100	43/100	- 28/100	0	1/7	0.66	7/10	0.24	2/10	23.84	45.00	168.54
	Ambroise	1000	120	0	706	706	421	-285	991	71/100	71/100	42/100	- 29/100	0	1/6	0.68	7/10	0.07	1/10	8.54	37.50	169.97
	ITC Bodoni Six	1000	120	0	693	695	445	-276	969	72/100	72/100	46/100	- 28/100	0	1/6	0.69	7/10	0.30	3/10	36.00	37.50	173.16
	Miller	1000	106	0	683	746	462	-226	909	82/100	75/100	51/100	- 25/100	0	1/6	0.63	6/10	0.35	3/10	36.74	42.45	175.70
average		1000	115		694	716	443	-262	956	75/100	73/100	46/100	- 27/100	0	1/6	0.67	7/10	0.24	2/10	27.60	39.02	172.91
Slab Serif	**OL Egiziano**	1000	130	0	750	750	404	-188	938	80/100	80/100	43/100	- 20/100	0	1/6	0.89	9/10	0.72	7/10	93.50	34.62	160.00
	Consort	2048	108	0	667	677	467	-200	867	78/100	77/100	54/100	- 23/100	0	1/6	0.83	8/10	0.49	5/10	52.51	85.40	368.46
	Joanna	2048	69	0	599	658	408	-244	843	78/100	71/100	48/100	- 29/100	0	1/9	0.50	5/10	0.45	5/10	31.19	133.86	410.20
average		1000	102		672	695	426	-211	883	79/100	76/100	48/100	- 24/100	0	1/7	0.74	7/10	0.55	6/10	56.54	44.01	312.89
Humanist Sans Serif	**English Egyptienne (excluded)**	1000	137	0	700	NA	NA	NA	700	700	1	NA	NA	0	1/5	0.95	9/10	0.63	6/10	86.64	32.85	171.43
	Gill Sans Nova	1000	75	0	682	682	449	-230	912	75/100	75/100	49/100	- 25/100	0	1/9	0.51	5/10	0.93	9/10	69.53	60.00	175.95
	Optima	1000	84	1	680	747	468	-263	943	79/100	72/100	50/100	- 28/100	0	1/8	0.47	5/10	0.37	4/10	30.67	53.57	176.47
	Sean/Canola	1000	78	0	722	800	533	-300	1022	78/100	71/100	52/100	- 29/100	1	1/9	0.67	7/10	0.82	8/10	63.77	57.69	166.20
average		1000	79		695	743	483	-264	959	77/100	72/100	50/100	- 28/100	0.3	1/9	0.55	5/10	0.70	7/10	55.56	56.96	172.88
Grotesk	**FF Bau**	2048	87	0	753	757	498	-197	950	80/100	79/100	52/100	- 21/100	0	1/9	0.69	7/10	0.81	8/10	70.40	106.04	326.40
	DIN	1000	76	0	712	712	492	-220	932	76/100	76/100	53/100	- 24/100	0	1/9	0.89	9/10	0.90	9/10	68.40	59.21	168.54
	Univers Next	1000	100	0	722	721	502	-193	915	79/100	79/100	55/100	- 21/100	0	1/7	0.69	7/10	0.79	8/10	79.29	45.00	166.20
average		1000	88		729	730	497	-203	932	78/100	78/100	53/100	- 22/100		1/8	0.76	8/10	0.83	8/10	73.12	51.35	220.38
Geometric	**Futura**	1000	85	0	754	825	470	-264	1018	81/100	74/100	46/100	- 26/100	0	1/9	0.50	5/10	0.96	1	81.42	52.94	159.15
	Semplicata	1000	72	0	757	820	481	-254	1011	81/100	75/100	48/100	- 25/100	0	2/21	0.49	5/10	0.88	9/10	63.52	62.50	158.52
	Gotham	1000	79	0	700	730	517	-160	860	85/100	81/100	60/100	- 19/100	0	1/9	0.71	7/10	0.90	9/10	71.02	56.96	171.43
average		1000	79		737	792	489	-226	963	82/100	77/100	51/100	- 23/100	0	1/9	0.57	6/10	0.91	9/10	71.83	57.20	163.03
AVERAGES		1000	95	0	699	739	457	-244	943	78/100	74/100	48/100	- 26/100	4.5	1/7	0.73	7/10	0.63	6/10	60.19	47.33	195.86
MINIMUM			69	0	599	658	383	-316	843	71/100	69/100	42/100	- 31/100	0	2/21	0.47	5/10	0.07	1/10	8.54	34.62	155.24
MAXIMUM			130	1	773	828	533	-160	1066	85/100	81/100	60/100	- 19/100	21	1/6	0.89	9/10	0.96	1	93.50	133.86	410.20

14. Annex 3

Typeface by Components

Case	Component name	Stroke Type	Shared Instances	Character Sharing
Mixed	Bar	Horizontal	15	A, E, F, G, H, L, Z, f, t, z
	1			
Uppercase	Cap_Bowl_High	Bowl	3	B, P, R
	Cap_C	Bowl	5	C, D, G, Q
	Cap_C_Terminal_Bottom	Terminal	1	C
	Cap_C_Terminal_Top	Terminal	2	C, G
	Cap_Serif_Angle_Low	Serif	4	A, V, W
	Cap_Serif_Angle_Low_Small	Serif	3	A, V, W
	Cap_Serif_Angle_R	Serif	1	Y
	Cap_Serif_Angle_X_Large	Serif	2	X
	Cap_Serif_Angle_X_Small	Serif	3	Y, X
	Cap_Serif_Apex	Apex	1	M
	Cap_Serif_Apex_Narrow	Apex	1	M
	Cap_Serif_Arm	Serif	2	E, F
	Cap_Serif_Double	Serif	17	H, F, I, J, K, L, M, P, R, T, U, Y
	Cap_Serif_Double_Narrow	Serif	4	U, M, N
	Cap_Serif_Single	Serif	11	B, D, E, F, L, M, P, R
	Cap_Serif_Single_Narrow	Serif	2	M, N
	Cap_Serif_Top_Vertical	Serif	10	E, F, L, T, Z, z
	Cap_Stem	Stem	16	B, D, E, F, H, I, J, K, L, M, P, R, T, U, Y
	Cap_Stem_Narrow	Stem	4	U, M, N
	Cap_Vertical_A	Diagonal	5	A, M, V, W
	Cap_Vertical_A_Narrow	Diagonal	5	A, M, V, W
	Cap_X_Arm	Diagonal	2	X, Y
	Cap_X_Arm_Narrow	Diagonal	3	X, Y
	G_Beard	Terminal	1	G
	23			
Lowercase	Low_C_Terminal_Top	Terminal	1	c
	Low_E_Final	Terminal	2	c, e
	Low_O	Bowl	6	b, c, d, e, p, q
	Low_Serif_Angle	Serif	3	k, x
	Low_Serif_Angle_Low	Serif	4	v, w, y
	Low_Serif_Angle_Low_Narrow	Serif	3	v, w, y
	Low_Serif_Angle_Narrow	Serif	3	k, x
	Low_Serif_Double	Serif	14	h, f, I, k, i, m, n, p, q, r
	Low_Serif_Foot	Serif	8	b, d, m, n, p, q, r, u
	Low_Serif_Foot_Turn	Serif	2	a, t
	Low_Serif_Top_Flag	Serif	10	b, d, g, h, i, j, k, l, u
	Low_Shoulder	Turn	10	h, m, n, u
	Low_Stem	Stem	8	b, d, h, k, l, p, q, t
	Low_Stem_Small	Stem	7	f, i, j, m, n, r, u
	Low_Terminal_S	Terminal	2	s
	Low_Turn	Turn	2	f, j
	Low_V_Arm	Diagonal	4	v, w, y
	Low_V_Arm_Narrow	Diagonal	4	v, w, y
	Low_X_Arm	Diagonal	1	k
	Low_X_Arm_Narrow	Diagonal	1	k
	19			