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Preserve our shared Cultural Heritage - Recorded data, writing systems, scripts: Greek Minuscule Font and Keyboard

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The product is available at:
https://github.com/ShiiraFT/GreekMinusculeFont

Introduction

The creation of a digital font based on a historical script constitutes an effort in pursuing to bridge the gap between past and present writing traditions[1]. The medium through which a script is transmitted may affect its perception by its intended receptors. Conversely, the stylistic choices surrounding writing style may determine the substance assigned to a medium by the individuals who interact with it[2]. Digitization projects conducted in professional and academic contexts may reinvigorate research interest surrounding historical scripts, with a pronounced impact on cultural studies[3].

The present essay represents an attempt in creating a digital framework for the use of a font, which was based on an 11th-12th c. manuscript in the Greek Minuscule script. As will be explained in the chapters that follow, an accompanying keyboard had to be developed, in order to best address the nuances of the writing style that was tackled. The steps for creating both the font and the keyboard will be discussed at length, in order to adequately address choices that had to be made in the designing phase. After technical specifications have been covered, further concerns will be highlighted, providing a framework for future refinement of the product. The final chapter will discuss the implications of creating a historical font for research, as well as public engagement, as alluded to in the opening statement.

An appendix has been incorporated, with tables that include information on Private Use Area Unicode values employed, as well as Keyboard combinations to achieve special characters and ligatures. A comprehensive list of referenced material has been included at the end of the document.

[1] Mansour – Hassan, 2020, 36.
[2] In a similar fashion, see: Brideau 2021, for an in-depth exploration of the functions of typography as a medium.
[3] Mansour – Hassan, 2020, 36.

The Greek Minuscule Script

The Greek Minuscule Script became the standard book-hand for manuscripts authored in the Byzantine Empire after the 9th c. CE[4]. Its roots followed a long tradition of cursive writing on papyri, though its exact development phases may not be traced due to lack of specimens[5]. The earliest examples of the script have been dated to the second quarter- to late 9th c. CE and were already distinctly mature in form and composition (Fig. 1)[6].

Though the free-hand-nature of the script meant that some degree of individuality could be expressed, scribes tended to be conservative in regards to the style of writing demonstrated[7]. Thus, diachronic changes could be observed but were gradual and cautious. That observation was particularly detectable in liturgical texts and church-books, whose thematic gravitas discouraged experimentation[8]. The major different styles of the script have been traditionally categorized into four periods or classes -the *codices vetustissimi* (9th-mid. 10th c.), the *codices vetusti* (mid. 10th-mid. 13th c.), the *codices recentiores* (13th-mid. 15th c.), and the *codices novelli* (15th c. onwards)[9].

Throughout its various stages, the Minuscule was generally characterized by the use of lower-case letters[10], though upper-case forms borrowed primarily by the uncial script[11] were gradually introduced[12]. Variant forms of letters were also present, meaning that the same character could potentially be represented with more than one glyph, even within the same manuscript[13]. Ligatures and abbreviations became progressively more common, with some being shared among different texts, while others appearing as *unica*[14].

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[4] Marcos 2024, 39.
[5] Thompson 1912, 218.
[6] Ibid. 219-220.
[7] Ibid. 220.
[8] Marcos 2024, 46.
[9] Thomspon 1912, 220.
[10] Marcos 2024, 46.
[11] For information on the uncial script, see: Thompson 2012, 198-217.
[12] The process seemingly begun by the end of the 9th c. and was completed by the middle of the 10th c. See: Marcos 2024, 46.
[13] Marcos 2024, 46.
[14] Marcos 2024, 42. Thompson 1912, 235.

In order to facilitate the creation of the font, a manuscript was selected that functioned as a base for glyph-design. The particular specimen utilized was the MS. Barocci 102 of the Bodleian Library -hence the name of the font. The content of the collection concerns a *Commentary on Isaiah by Basil the Great*, transcribed around the late 11th to early 12th c. CE[15]. It represents a clearly-written example of contemporary minuscule writing, with a freer hand. Additionally, it has survived in fairly good condition and is thus quite readable (Fig. 2). The manuscript has been fully digitized and made accessible online in high quality images[16]. A transcription of some pages has been made available as well[17], which allowed for the document to be de-coded and read. That particular aid was especially helpful in recognizing complex ligatures, or even unusual letter designs that the author was not familiar with.

[15] Lucà 2011, 64.
[16] Oxford 2016.
[17] Platanou et al. 2022.

Designing the Font

Two main software were employed for designing the glyphs, each for their unique affordances in approaching the complex issue of creating a font based on a handwritten-text. First, Inkscape v. 1.3.2 was used, and specifically the SVG Font Editor Tool. Images of the manuscript-pages were inserted into the application, and recognized letters were traced to create the appropriate glyphs. The values of the Modern-Greek Unicode alphabet were assigned to the corresponding lower-case and upper-case signs[18]. When a variant form of a letter was detected, it was assigned a Unicode value from the Private Use Area (PUA) in alphabetical order[19] (T.1). The produced glyphs were then examined against other instances within the manuscript, including in different pages, to ensure that they depicted a representative example of the letter (Fig. 3).

Ligatures were also assigned PUA values, and were named following the appropriate letter combinations. A concern that had to be addressed related to the character substitutions that would have to occur, in order for them to be produced. By examining the document thoroughly, it was made obvious that not all instances of letter-sequences that may combine, always did so. As such, it could not be the case that each time a simple (or variant) form of two (or more) letters met, they would be substituted. In order to circumvent that problem, "combining"-characters were utilized. The former referred to glyphs corresponding to the first letter of a ligature, that was assigned a unique PUA value (T.1). For aesthetic purposes, a dotted circle (◌ - U+25cc) was inserted where the following letter would be positioned. That approach has been utilized thoroughly in implementations for languages that require frequent substitutions[20], and will be tested further for the project at hand.

The produced SVG-font file was then inserted into FontForge v. 20230101, wherein it was refined. The processing model developed by Martin Hosken was followed[21], as the use of

[18] Greek and Coptic, 2.
[19] Private-Use Characters.
[20] Allen et al. 2012, 573.
[21] Hosken 2003.

a smart, OpenType font was considered *sine qua non*. As explained above, substitutions needed to be considered during that step too. For this particular project, that concerned ligatures and diacritics. Towards the former, the Ligature Substitution Lookup tool within FontForge was taken advantage of, and specifically the "liga Standard Ligatures" feature. The source-glyphs for each combination-lookup corresponded to the appropriate combining character value, and the value for the following letter(s) in standard Greek Unicode for lower-case encoding.

Another major area of deliberation in terms of substitutions, would relate to the use of diacritic marks. The Greek language is accented, and various signs have been used historically to denote tonal emphasis or expected pronunciation[22]. At the time that the manuscript was transcribed, a polytonic system was employed for written texts, with five corresponding diacritics[23]. One approach in Unicode Standard would relate to the use of precomposed glyphs that already combine the letters with the marks, in all possible combinations[24] -as a letter may carry one pitch accent and one breathing mark simultaneously. A different approach could relate to the use of combining characters that exist individually, but may be anchored in correct positions in relation to the letters they are meant to mark[25].

For the purposes of the current project, the latter solution was deemed most appropriate (T.3). That stemmed from the observation that it would negate the need to individually design each possible letter or ligature and diacritic combination, providing a more efficient solution to the issue at hand. However, anchoring could pose yet another cause for concern. The positioning of diacritic marks was often cluttered and disorderly within the manuscript, escaping proper locality, as they may have appeared on top of preceding or following letters (Fig. 4). For the sake of simplicity, a digital transcription was necessary, meaning that the marks would be anchored at an anticipated position in relation to corresponding letters,

[22] Οικονόμου 1971 17-22.
[23] It should be noted that the use was historical, rather than practical, outside the standard accent mark -the acute accent. Differences in pronunciation relevant to diacritics had already become obscure in spoken language.
[24] Greek Extended.
[25] Combining Diacritical Marks.

despite deviation from manuscript standard. Existing encoded combining diacritics were utilized with the appropriate sign, inspired by the manuscript[26].

After substitutions were sufficiently addressed, positioning had to be reviewed. First, fundamental cardinalities were fixed, in terms of height, base-line positioning, width, and advance. As the letters in minuscule manuscripts most often connected[27], the width line specifically was set very close to the outline of the glyphs, while in some cases it was decided that it should even run on top of the letter, to allow for continuity. Kerning rules were also set, to further enhance the described processes, and achieve a more cohesive result. Page and paragraph-formatting could also be similarly convoluted, as the words often escaped the layout of the page in the original manuscripts (Fig. 5)[28]. In order to enable seamless transition to modern digital word processing programs, simplified and expected characters and line-breaking formats were instead adopted.

After completing the aforementioned processes, meta-data was added to the font, referring to appropriate name and characteristics, authorship and running version. The outcome of the effort related to the OpenType font “MS. Barocci 102”. As alluded to, an OpenType Font Format (CFF) was favored to best suit the particular needs of the project. OpenType Fonts generally allow for more seamless integration of complex glyph collections and intra-collection glyph interactions, including glyph substitution and ligature formation[29]. Simultaneously, they are interoperable between different devices and operating systems, facilitating the publication of the product[30].

[26] Combining Diacritical Marks.
[27] Thompson 1912, 235.
[28] Priest 2003.
[29] ISO/IEC 2014, 1.
[30] Ibid.

Developing the Keyboard

In order for the font to be utilized to its greatest extent an accompanying keyboard would have to be created[31]. The software Keyman Developer v. 17.0.326 was employed for that purpose, as it permitted the development of the relevant interface, without a prerequisite for high-level coding capabilities. A Keyman .kps package was created, that included affordances for a physical and on-screen keyboard, as well as touch-screen keyboards for smartphones and portable tablet devices. The font was included into the package, as required for a successful integration.

The standard Greek keyboard was used as a base for the project, as most characters could be mapped directly onto it, without the need to stray for the original format. For the physical and corresponding on-screen keyboard, all slots were used for the lower-case letters, along with the few slots for the upper-case variants (Fig. 6). The absence of a number of expected characters made it possible to incorporate the extra glyphs that are particular to the font (T.2). Initially, that process concerned added variants of letters, that were mapped onto the number-keys in alphabetical order, at the top of the keyboard. Consequently, the combining-characters had to be integrated. The decision was made to produce the combining-characters by pressing the SHIFT-key, along with a number-key, also in alphabetical order (i.e.: SHIFT_KEY + KEY_1 combination would result in the glyph combining gamma). When inserting the combining character, the keyboard can recognize its Unicode value and substitute it with the correct glyph to create the desired ligature, in accordance to the next letter that will be inputted. Thus, the user has a visual clue as to which character they wish to start the ligature with, while also retaining the capability to insert the uncombined letters next to each other[32].

[31] Essentially, in order to effectively implement special symbols and ligatures.

[32] The idea of using a single combining feature, such as the "*" (U+002A) sign was also explored, so as not to populate the keyboard. In theory, the first letter that comprised the ligature would be typed, followed by an asterisk, to produce the combining sign, then finally the following letter. However, the Keyman Developer could not properly handle the complex combination, rendering the software unstable and causing the application to crash often. Further experimenting with a more straight-forward solution will need to be carried out, for the sake of posterity.

The diacritics were mapped on the keys that are standard for Ancient Greek Polytonic Keyboards on Windows devices (T.3)[33]. The marks should be added after the letter has been typed, in the order of breathing then accent mark, so as to be displayed properly. No specific rules could be set in terms of what letters should or should not receive a sign. As such, even consonants may be accented for example, despite linguistic inaccuracy.

The aforementioned configuration enabled the direct use of the font utilizing a typical, physical keyboard, thus constituting it accessible to a wider pool of users. However, on-screen keyboards for smartphones and tablet devices were also considered vital to formulate, with a two-fold purpose in mind. First and most obviously, to enable and refine the use of the font on touch-screen devices. Secondly, to propose an alternative approach to the issue of variant characters and ligatures. In the latter scenario, the template formed for the physical keyboard was somewhat altered, in that the number-keys were cleared, both in the standard and the shift layer. Instead, the relevant glyphs were integrated into long-press keys that pop up when interacting with the appropriate letter -either the basic form of a variant, or, in the case of ligatures, the first letter that would form them (Fig. 7).

The project was packaged and the compiled keyboard was thoroughly tested, primarily in the Keyman Developer Server provided by the application and run locally. Possible issues could be detected and fixed directly within the software. Broader complications that could be encountered often had to be fixed within the font itself, requiring that it be updated to adequately address them. Such problems most commonly referred to incorrect spacing between characters or unsuccessful kerning. When a satisfactory practical and visual result was achieved, the keyboard was also tested on word processors, such as Microsoft Word and Google Docs, with ligatures enabled when possible. The keyboard package developed was sent to testers with experience in Greek Paleography to ensure the validity of the endeavor, as well as basic functionality[34]. The products have been uploaded on a GitHub

[33] Typing Ancient Greek.

[34] The testers concerned four users, with varied experience in Greek Paleography and excellent knowledge of the Greek language diachronically:

a. An academic and PhD candidate in (Digital) Byzantine Studies and Sigillography, from the University of Cologne, Germany.
b. An M.A. student of Byzantine History, from the University of Vienna, Austria.

repository and made available publicly, along with relevant documentation and instructions.

c. An M.A. graduate of Philosophy, from the University of Athens, Greece.
d. An M.Sc. student of Environmental Studies and Sustainability Science, from the University of Lund, Sweden.

Their support and feedback are greatly appreciated. A more thorough survey, with a greater number of test-users from more varied backgrounds would be highly beneficial to the endeavor.

Refinements and Additions

As described in the previous chapter, the font and keyboard can be used to a satisfactory level, also attested by the external users. Nonetheless, there remains potential for further development and refinement in the longer term. Primary areas of improvement could be identified from observation of the fundamental product-characteristics. Feedback received from the test-users also aids to illuminate deficiencies, while highlighting creative ways to enhance the end-product.

A first major point could be raised for more advanced kerning and relative positioning[35]. Though there was an attempt to properly regulate kerning rules, in practice not all conceivable connections could be examined for accuracy, especially as FontForge did not display the characters in the lookup table when setting their new relative position (Fig. 8), constituting the endeavor a course of trial-and-error. The same could ring true more generally for spacing between characters, as variation in probable representations could be expected. Additionally, many letters also existed that fell completely outside the baseline of the handwritten text, either floating slightly above it, or lodged between lines (Fig. 5). As the font is meant to be used in a more standardized manner, such irregularities were left unaddressed.

On a more practical level, new character variations, ligatures, special characters and symbols would have to be detected and appended to the list of glyphs. Examining different texts from the same era, wherein variant designs and combinations may be more common would be necessary, to ensure that the product would accurately represent the state of the script. In order to avoid confusion on that regard, the label “MS. Barocci 102” was favored in naming the font and keyboard, instead of a more general “Greek Minuscule”. Though the manuscript would be representative as explained previously, it would be misleading to suppose that the created product could fully represent the Greek Minuscule, at least at its current state.

[35] Hosken 2003.

Discussion and Concluding Remarks

The creation of a historical font can significantly impact related academia, in a multitude of creative directions. Similar efforts have focused on the affordances offered by such endeavors in regards to diplomatic transcriptions of texts[36]. Accurate depictions of glyphs from historical documents in scientific papers enable more faithful transfer of information. That procedure encourages research in corresponding fields by aiding in better contextualizing specimens[37], as stylistic choices may betray aspects of chronology, locality, and scribal identity[38]. Implementations utilizing historical fonts may provide scholars with an opportunity to grasp the nuances of handwriting in manuscripts more comprehensively[39]. By interacting with the font, the user may gain insight into scribal conventions such as stroke order and speed, which in turn may elucidate choices regarding glyph formation within a given document[40].

Taking that thought a step further, fonts may be used to streamline processes of recognizing scripts and de-coding handwritten manuscripts by employing them in Deep-Learning Networks[41]. Handwritten Text Recognition (HTR) constitutes an arduous process that may be impeded by the nature of free-hand practices[42]. Making use of a font with encoded glyphs that would otherwise be difficult to recognize, may prove a powerful tool for automatic transcriptions[43] and advanced queries in online databases[44]. The publication of fonts based on historical writing styles may offer significant support to conservation efforts

[36] Related case-studies concern: The AthenaRuby Project, for the transcription of Byzantine Inscription (Kalvesmaki 2015, Sopracasa et al. 2020). The Fonts for Scholars Project, for the transcription of transcriptions in Classical, Biblical, Medieval Studies and Linguistics (Perry 2010). The Greek Paleography Project, for the transcription of Medieval Manuscripts (Marcos 2024). The Medieval Unicode Initiative (MUFI) for the encoding of special characters in Medieval texts in the Latin alphabet (Everson et al. 2006).
[37] Sopracasa et al. 2020, 113-114.
[38] Everson et al. 2006, 1-2.
[39] Ibid. 2.
[40] Everson et al. 2006, 1-2. It would be interesting to study the ways in which information encoded within a given historical font impact the user's perceived understanding of the original script. That could refer to kerning and ligature formation, as related to stroke order and speed of writing in handwritten manuscripts, as an example.
[41] Gupta et al. 2016. In which the researchers explore the use of an active-learning labeling system for recognizing known fonts, in order to facilitate digital documentation of historical documents.
[42] Gupta et al. 2016, 2. Pavlopoulos et al. 2023A, 7818-7819.
[43] Gupta et al. 2016.
[44] Sopracasa et al. 2020, 117.

that attempt to highlight the histories of scripts that remain underrepresented in digital typography[45].

Moving away from professional scholarship, similar effects could potentially be observed in students engaged in historical studies, but also interested individuals from unrelated backgrounds. Public engagement is a *desideratum* for the advancement of culture studies and such initiatives may help familiarize non-specialists with the source material and research directions of academic studies. At the same time, the former would have the potential to encourage the active and creative interaction with past scribal traditions, in the context of cultural education[46]. Integration of fonts in digital teaching-environments may afford a considerable learning opportunity, for students interested in decoding manuscripts[47]. Studying the manner in which digitized historical fonts influence public perception of past cultures would constitute a fascinating research area[48].

Undoubtedly, there remains room for significant improvement in the present endeavor. Beside technical aspects that could be refined, the context and implications of creating the font would need to be deliberated over to a greater degree. Such an approach would signify a more conscious attitude towards creating what is essentially a cultural product, that may be scrutinized in the framework alluded to.

[45] Mansour – Hassan 2020, 36.
[46] Gokulnath 2024.
[47] Kamp 2009.
[48] Karahan 2024.

Figures

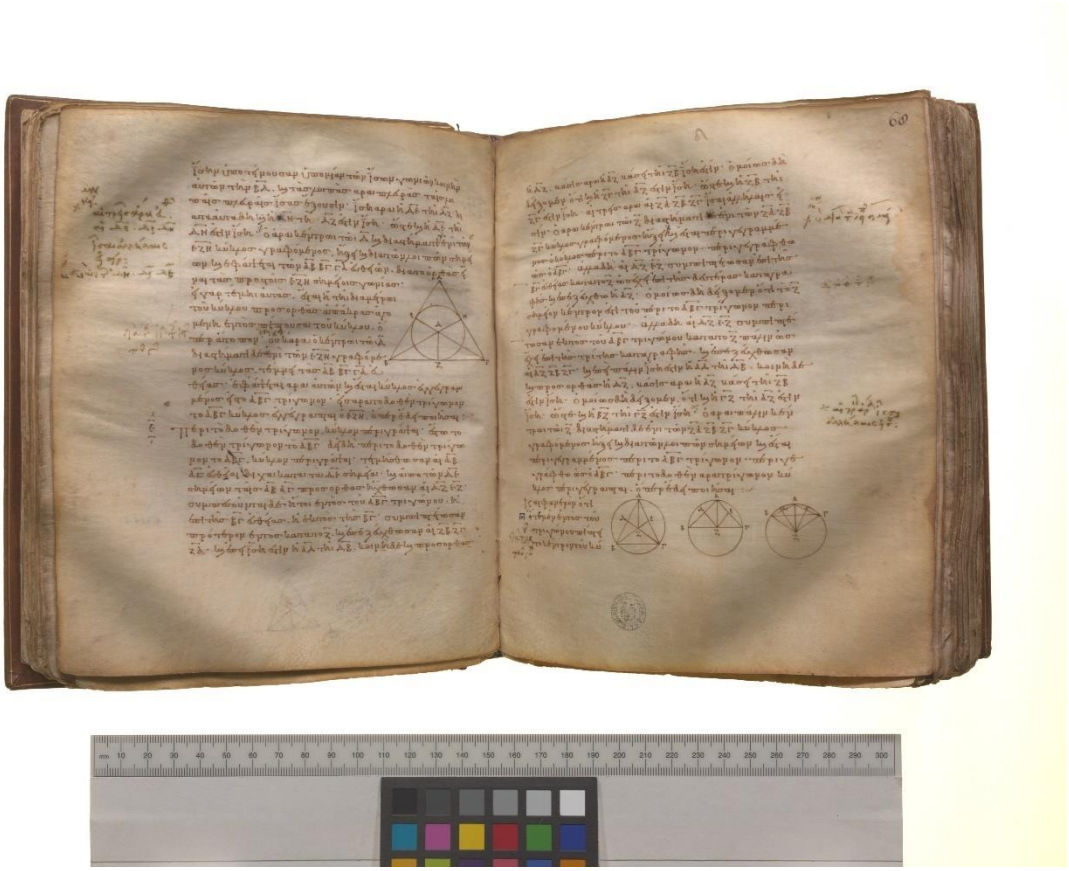

Figure 1. Euclid Elementa Manuscript, dated in 888 CE. One of the earliest and most complete examples of Greek Minuscule. Bodleian Library MS. D'Orville 301, fol. 67v-68r. (Oxford 2018).

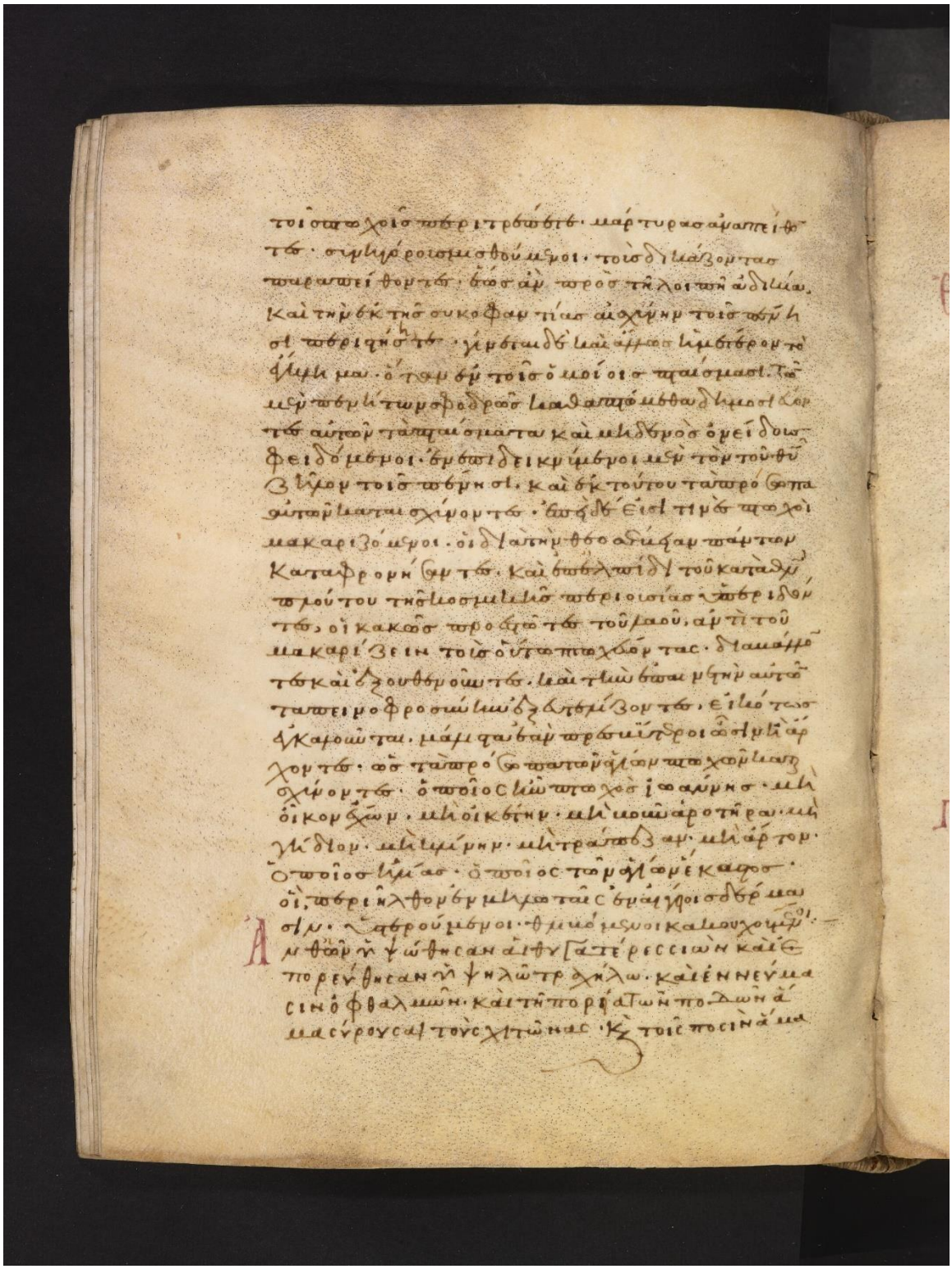

Figure 2. Commentary on Isaiah from Constantinople, dated to the late 11th-early 12th c. Bodleian Library MS. Barocci 102, fol. 75v (Oxford 2016).

Figure 3. Example of letter traced on top of manuscript page in Inkscape.

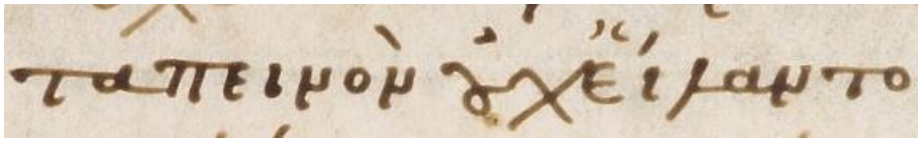

Figure 4. Example of diacritics that escape expected position. In the word «ταπεινὸν» the grave accent appears on top of the character «ν». A smooth and a rough breathing coexist on top of the character «ε». Detail from the Bodleian Library MS. Barocci 102, fol. 75v. (Oxford 2016).

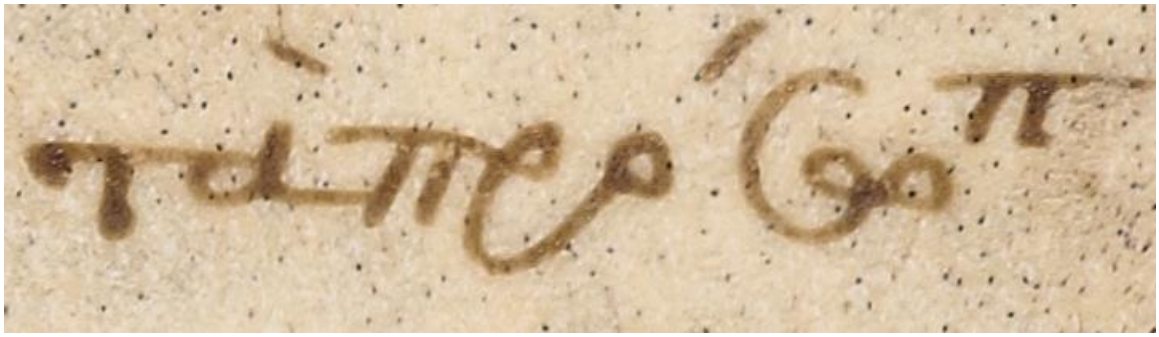

Figure 5. Example of letter that escapes expected baseline. In the word "πρόσωπ(α)" the final «π» appears higher than the rest of the line. Detail from the Bodleian Library MS. Barocci 102, fol. 76r. (Oxford 2016).

Figure 6. On-screen Keyboard Layout.

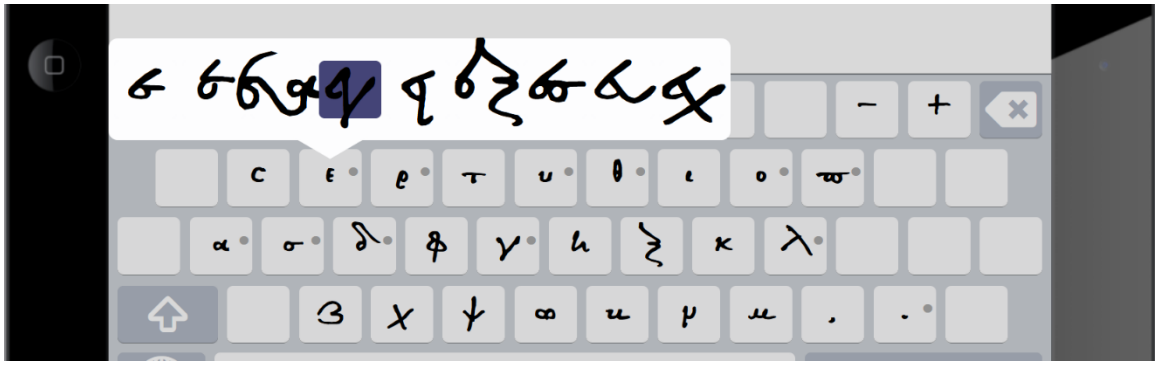

Figure 7. Touch-screen Keyboard Layout. Example with letter that has variants and forms ligatures.

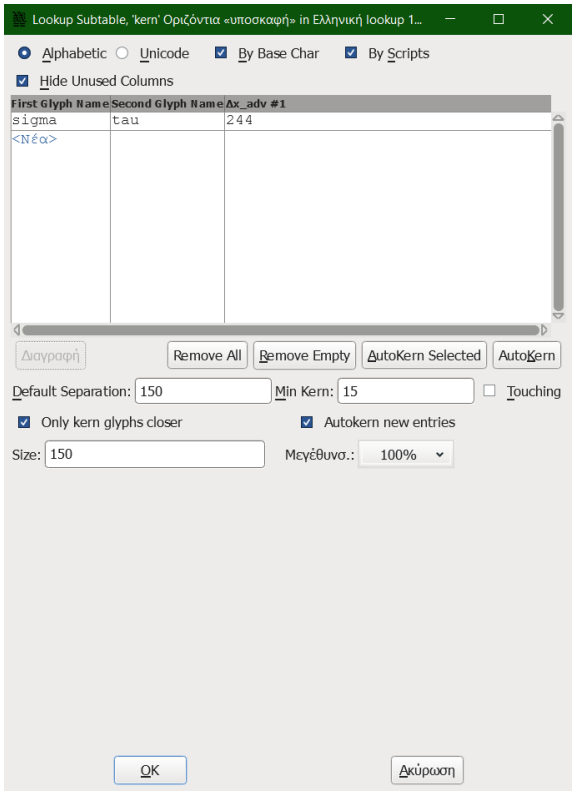

Figure 8. Kerning Lookup Subtable not appearing correctly in FontForge.

Appendix

T.1. Added Characters in Unicode Private Use Areas

Character Name	Corresponding Letter	Unicode Value	Character Sign
Alternate Alpha #1	α	U+E04A	
Alternate Alpha #2	α	U+E040	
Alternate Epsilon #1	ε	U+E041	
Alternate Epsilon #2	ε	U+E042	
Alternate Theta	θ	U+E043	
Combining Gamma	γ.	U+E044	
Combining Delta	δ.	U+E045	
Combining Epsilon	ε.	U+E046	
Combining Lambda	λ.	U+E047	
Combining Omicron	ο.	U+E048	
Combining Pi	π.	U+E049	
Combining Rho	ρ.	U+E04B	
Combining Sigma	σ.	U+E050	
Combining Upsilon	υ.	U+E051	
Ligature Gamma Omicron	γο	U+E05A	
Ligature Gamma Omega	γω	U+E053	
Ligature Delta Alpha	δα	U+E054	
Ligature Epsilon Alpha	εα	U+E055	
Ligature Epsilon Gamma	εγ	U+E056	
Ligature Epsilon Iota	ει	U+E057	
Ligature Epsilon Xi	εχ	U+E058	
Ligature Epsilon Sigma	εσ	U+E059	
Ligature Epsilon Upsilon	ευ	U+E060	
Ligature Epsilon Chi	εχ	U+E061	
Ligature Lambda Omicron	λο	U+E062	
Ligature Lambda Omicron Iota	λοι	U+E063	

Ligature Omicron Upsilon	ου	U+E064	
Ligature Pi Tau	πτ	U+E065	
Ligature Rho Iota	ρι	U+E069	
Ligature Rho Omicron	ρο	U+E06A	
Ligature Sigma Tau	στ	U+E066	
Ligature Sigma Omega	σω	U+E067	
Ligature Upsilon Nu	υν	U+E068	
Ligature Upsilon Psi	υψ	U+E06B	

T.2. Added Ligatures – Keyboard Input

Ligature Name	Keyboard Input	Keyboard Input Unicode Values
Ligature Gamma Omicron	[SHIFT K_1] [K_O]	U+E044 U+03B3
Ligature Gamma Omega	[SHIFT K_1] [K_V]	U+E044 U+03C9
Ligature Delta Alpha	[SHIFT K_2] [K_A]	U+E045 U+03B1
Ligature Epsilon Alpha	[SHIFT K_3] [K_A]	U+E046 U+03B1
Ligature Epsilon Gamma	[SHIFT K_3] [K_G]	U+E046 U+03B3
Ligature Epsilon Iota	[SHIFT K_3] [K_I]	U+E046 U+03B9
Ligature Epsilon Xi	[SHIFT K_3] [K_J]	U+E046 U+03BE
Ligature Epsilon Sigma	[SHIFT K_3] [K_S]	U+E046 U+03C3
Ligature Epsilon Upsilon	[SHIFT K_3] [K_Y]	U+E046 U+03C5
Ligature Epsilon Chi	[SHIFT K_3] [K_X]	U+E046 U+03C7
Ligature Lambda Omicron	[SHIFT K_4] [K_O]	U+E047 U+03BF
Ligature Lambda Omicron Iota	[SHIFT K_4] [K_O] [K_I]	U+E047 U+03B1 U+03B9 or U+E062 U+03B9
Ligature Omicron Upsilon	[SHIFT K_5] [K_Y]	U+E048 U+03C5
Ligature Pi Tau	[SHIFT K_6] [K_T]	U+E049 U+03C4
Ligature Rho Iota	[SHIFT K_7] [K_I]	U+E04B U+03B9
Ligature Rho Omicron	[SHIFT K_7] [K_O]	U+E04B U+03B3
Ligature Sigma Tau	[SHIFT K_8] [K_T]	U+E050 U+03C4
Ligature Sigma Omega	[SHIFT K_8] [K_V]	U+E050 U+03C9
Ligature Upsilon Nu	[SHIFT K_9] [K_N]	U+E051 U+03BD
Ligature Upsilon Psi	[SHIFT K_9] [K_C]	U+E051 U+03C8

T.3. Diacritic Marks – Unicode Values and Keyboard Input

Diacritic Name	Unicode Value	Unicode Character Name	Keyboard Input	Character Sign
Acute Accent	U+0301	Combining Acute Accent	[K_COLON]	
Combining Grave Accent	U+0300	Combining Grave Accent	[K_ RBRKT]	
Circumflex	U+0303	Combining Tilde	[K_LBRKT]	
Smooth Breathing	U+0313	Combining comma Above	[K_BKQUOTE]	
Rough Breathing	U+0314	Combining Reversed Comma Above	[K_QUOTE]	

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