Towards a medieval palaeographical scale (1300–1550)

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In 1974 the well known Dutch palaeographer J. P. Gumbert remarked, in his inaugural address at the University of Leiden, that 'a precise knowledge of the morphology of script – one should say: a first necessity – is as yet non-existent, especially with regards to the later Middle Ages'[1]. It is remarkable that it is still entirely possible to make the same remark today without raising too many eyebrows. In the meantime many important contributions towards describing the morphology of medieval script have been made, but its late medieval evolution in particular remains to be thoroughly explored. What is more: the exploration of late medieval script as it occurred in documentary sources has hardly even begun.

In describing the morphology of script and its evolution, palaeography, in its nascent digital capacity or in its more 'traditional' form, has always been focused on literary sources – especially were the later Middle Ages are concerned. It wouldn't go too far to state that the palaeography of documentary sources of the later Middle Ages, in particular from the second half of the fourteenth century onwards, is still very much *terra incognita*. The reasons for this blank spot in our knowledge are not hard to fathom. After the relatively clear cut and traceable emergence of Gothic cursive as the dominant new script type in documentary sources in the thirteenth century it gets lost 'im undurchdringlichen Dickicht der massenhaften archivalischen Überlieferung', as one scholar wrote[2]. In other words, the number of archival sources extant from the later Middle Ages is simply too large, and local and regional variations in scripts used for administrative purposes too many – defying any attempt to systematically describe them. Reason enough for Derolez, for example, not to include documentary scripts in his survey of the history of Gothic scripts[3].

Another reason that late medieval documentary scripts are still unexplored, might pertain to the gulf that exists between codicology and diplomatics[4]. Despite many pleas in favor of conquering the divisions between the different branches of palaeography[5], it still tends to serve its different masters with different agendas in mind. Used as a tool of diplomatics, palaeography has always been and still is preoccupied with handwriting identification, being part and parcel of the forensic approach to its sources – first and foremost: charters – so characteristic for diplomatics. But since medieval charters usually are dated and relatively

[1] 'Van een precieze kennis van de morfologie van het schrift – men zou toch zeggen: een eerste voorwaarde – is met name voor de latere middeleeuwen nog geen sprake', J. P. GUMBERT, Schrift, codex en tekst. Een rondgang door codicologie en paleografie, Leiden 1974, 7.

[2] W. HEINEMEYER, Studien zur Geschichte der gotischen Urkundenschrift, Köln 1962, 128.

[3] A. DEROLEZ, The Palaeograpy of Gothic Manuscript Books. From the twelfth to the early sixteenth century, Cambridge 2003, 4.

[4] As has been noted by J. BURGERS, Palaeography and diplomatics. The script of charters in the Netherlands during the fourteenth and fifteenth centuries, in: Quaerendo 38 (2008), 9–31, 10–11.

[5] Most recently: BURGERS, Palaeography and diplomatics, 10–11; cf. J. MALLON, Qu'est-ce que la paléographie, in: Paläographie 1981: Colloquium des Comité International de Paléographie, München, 15.–18. September 1981, 47–52.

easily localized – although there are exceptions to this rule – an analysis and description of the morphological evolution of their script isn't of immediate practical use, since there is no urgent need to develop a corpus of reference knowledge that can be used to date and localize these sources. In its capacity of handmaid of codicology on the other hand, palaeography naturally focuses on the questions codicologists ask, and these *indeed* often involve dating and localizing, since so many literary sources extant from the Middle Ages don't carry a date or an indication of their place of origin. It is therefore highly desirable to classify and describe book scripts according to their morphological characteristics in order to trace their evolution and obtain a way of dating and localizing individual manuscripts – which palaeography has been attempting ever since Jean Mabillon founded the discipline.

Unfortunately, the effort to develop methods of dating and localizing medieval manuscripts hasn't been an unqualified success. This applies even more so for manuscripts dating from the later Middle Ages, that is: the vast majority of them. One of the most important reasons for this is simply that, despite the many volumes of *Manuscrits datés* that have now appeared, the number of surviving manuscripts that *do* carry a date and a place of origin is still too small to allow for the construction of what has been called a palaeographical 'scale', a corpus of reference knowledge about the evolution of letter forms and other script elements, situated with relative exactness in time and place, that could be used to date and possibly also localize undated manuscripts of unknown origin[6].

However, there is a way around this, that is: by turning to documentary sources and more specifically charters, which the late medieval Latin West has bequeathed to us by the hundreds of thousands. What is more, charters are usually dated and often relatively easily localized. They are, in fact, the only sources from the late Middle Ages that have survived in sufficient numbers to allow for the assemblage of a large enough, statistically significant corpus of different writing hands, without any chronological blind spots, that could convincingly be held to adequately represent the evolution of script in any given locality.

There is more to be said in favor of using the development of documentary script as a general palaeographical benchmark. The perceived gulf between administrative writing and book writing is, after all, turning out to be much smaller than previous generations of scholars maintained[7]. Books and administrative documents were often written by the same people. The scribes keeping records in the cities could very well be producing manuscripts as well, as has shown to be quite common in, for example, the Dutch city of Leiden – a striking example in this regard being the fifteenth-century Leiden scribe Huge Claesz Scriver, whose career as a writer employed by the city magistrate, local nobility and several religious and charitable institutions spanned three decades[8]. Apart from this, the simple fact is that most late medieval books were written in the same cursive script type typically used in administrative sources,

[6] BURGERS, Palaeography and diplomatics, 10; J. P. GUMBERT, Writing and dating – some general remarks, in: Scriptorium 54 (2000), 5–8.

[7] E. KWAKKEL, Die Dietse boeke die ons toebehoeren: de kartuizers van Herne en de productie van Middelnederlandse handschriften in de regio Brussel (1350–1400), Leuven 2000, 162–170.

[8] E. VAN DER VLIST et al., Stad van boeken. Handschrift en druk in Leiden, 1260–2000, Leiden 2008, 75–78; BURGERS, Palaeography and diplomatics, 11–12.

albeit with a generally higher level of execution[9]. There is, in any case, no reason to suppose that the cursive scripts used in keeping records developed in a way that was fundamentally different from the way these same scripts developed in books. It even remains to be seen if the conventional wisdom is true that script was constantly in flux in the documents and tended toward standardization in books[10]. We should, in any case, refrain from regarding documentary script as an isolated, separate script type – let alone a palaeographically irrelevant one. When terms as 'documentary script' or 'charter script' are used in this article, therefore, they denote no more than the 'script occurring in documents' or the 'script occurring in charters', the underlying assumption being that there was *no* separate charter script or documentary script, with its own set of characteristics[11].

There are, in balance, many pressing reasons to make haste with a serious exploration of the script occurring in late medieval documents. The present inquiry aims to contribute to this. We will analyze the development of a number of palaeograpical phenomena occurring in charters originating from the Dutch language area in the period circa 1300 to circa 1550. Using the knowledge thus gained it will lay out the groundwork of a future medieval palaeographical 'scale', which can be used to date undated documents as well as literary sources.

Sources

As it would be impossible to assemble a workable corpus of documents in which every municipality or region of the Dutch speaking Low Countries is represented, a selection was made of four cities and their archives: Leiden (Regionaal Archief Leiden), Arnhem (Gelders Archief), Louvain (Stadsarchief Leuven) and Groningen (Groninger Archieven). In the case of Groningen extensive use was also made of the online *Cartago* collection of charters (www.cartago.nl). No material outside of these archival collections was included. (App. 1)

There is, of course, some arbitrariness in choosing these four cities instead of any other. The way documentary script developed in any one of them isn't necessarily typical for the way it developed anywhere else. Nevertheless, these cities are geographically just about as far removed from each other as possible within the medieval Dutch language area – representing, so to speak, four of its 'corners' – which offers us, if not a cross-section of the evolution of late medieval administrative writing in the Low Countries, at least the best chance to bring regional differences or shifts to light. On the other hand, it stands to reason that if no fundamental differences between these cities in terms of script evolution come to light, we can, with some degree of confidence, extrapolate – or even: duplicate – our findings to other regions of the same language area.

To be sure, in this article *only* charters will be taken into account. Although charters form, by any account, the largest category among late medieval documents bequeathed to us, there are of course numerous other documentary source types from the same era, such as minutes,

[9] DEROLEZ, The Palaeography, 142. The Dutch situation is somewhat peculiar however, at least for the fifteenth century, considering the importance of so called *Hybrida* script.

[10] Ibidem, 5.

[11] See also section *status questions: the problem of script types*.

accounts, city, notary or chancellery registers, cartularia and letters. For the sake of uniformity and to avoid an unwieldy and widely diverging research corpus, these sources were not scrutinized. The corpus therefore only contains original charters (id est *grosses*) produced in Groningen, Arnhem, Leiden or Louvain, originating from the period between 1300 and 1550 – thereby covering what is patently the least explored period in the history of medieval documentary script, and following up on research into thirteenth-century documentary palaeography in the Dutch language area already done[12].

Determining the provenance of charters, in geographical terms, entails some complications. As we are, as a rule, only concerned with charters written in one of the aforementioned cities a method of localization is required. In most cases this method can be fairly straightforward, since the overwhelming majority of late medieval charters left to us through the aforementioned archival collections were issued by the city magistrates – usually by the city aldermen ('schepenen') in the case of Leiden, Arnhem and Louvain, and by the mayors and council ('burgemeesters en raad') in the case of Groningen[13]. Localizing these municipal charters is usually possible by applying the so called *classical* method of localization[14]. This method starts with comparing the handwriting found in a set of charters, and basically states that when two or more charters are written by the same hand and issued by the same institution or party while being addressed to different recipients (destinatarii) we can conclude that these charters were produced in the immediate vicinity of the issuer. When, however, two or more charters written by the same hand have different issuers but are addressed to the same recipient we can conclude they were produced in the immediate vicinity of that recipient. Since the municipal charters in the corpus scrutinized here were mostly written by scribes who produced whole series of them, issued by the same 'schepenen' or 'burgemeesters en raad' and addressed to different recipients, localizing them is fairly clear-cut.

Still, the classical method of localization was applied somewhat lenient, since a strict application requires that the different recipients of a set of charters issued by the same party, written by the same hand, should have no palpable relationship to one another in order to positively attribute the production of these charters to the circle of the issuer[15]. This is, obviously, often not feasible with municipal charters, since in many cases the parties mentioned in such a charter as recipient or beneficiary can be localized within the same city as the issuer and have diverse mutual relationships with both each other and the issuer. Although in these cases there can be no localization using the classical method *stricto sensu*,

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[12] See mainly J. BURGERS, De paleografie van de documentaire bronnen in Holland en Zeeland in de dertiende eeuw (Schrift en Schriftdragers in de Nederlanden in de middeleeuwen 1), Leuven 1995.

[13] Although these are by far the most frequent, the exact combination of types of magistrates by whom these municipal charters are issued can vary however – 'schepenen' however *never* occur in charters from Groningen.

[14] For a recent exposition of the 'classical' method of localization, originally devised by Bresslau and coined as such by Kruisheer, see E. DIJKHOF, Het oorkondewezen van enige kloosters en steden in Holland en Zeeland, 1200–1325 (Schrift en Schriftdragers in de Nederlanden in de Middeleeuwen 3), Leuven 2003, 32–43, en G. VAN SYNGHEL, 'Actum in camera scriptorum oppidi de Buscodensis'. De stedelijke secretarie van 's Hertogenbosch, Leiden 2006, 21–22; cf. H. BRESSLAU, Handbuch der Urkundenlehre für Deutschland und Italien, 2 vols., Berlin 1958, 1, 41–43, en 2, 355–361; J. KRUISHEER, Kanzleianfertigung, Empfängeranfertigung und Anfertigung durch Dritte. Methodologische Anmerkungen anlässlich einiger neuerer Untersuchungen, in: AfD 25 (1979), 256–300, 261.

[15] Cf. DIJKHOF, Het oorkondewezen, 41.

there is usually little room for doubt that these charters were produced within the city at hand, which is our main concern.

Although the majority of the charters in our corpus (circa 80%) were issued by city magistrates there are many other issuers in the set of charters under consideration here, among which clerics, notaries, and (representatives of) clerical or charitable institutions. Using the classical method becomes more tenuous, however, when there are only a few charters written by the same hand available – as it is often the case with these issuers. When necessary, therefore, the contents of the charters at hand were also scrutinized in order to substantiate the procedure of localization. Where a hand is known to us through only one charter, excluding a localization using the classical method, this becomes especially relevant. Instead of excluding these hapaxes, provenance was attributed based on content, that is to say: when both the issuer and the recipient(s) or witnesses were – as apparent from the contents of the charter itself or by cross referencing – demonstrably localizable within a certain city, this charter was taken to be produced locally.

Admittedly, this procedure of localization is not watertight. It doesn't take into account the well known mobility of clerks in this era for example, or the fact that it is entirely possible for a clerk to have more than one employer[16]. Nothing excludes, furthermore, a clerk growing up in, say, Louvain and afterwards finding employment in Groningen. Reservations are, therefore, in order, but this doesn't change the fact that some geographically narrowing down is required, both in order to trace possible differences in local scribal practices and in order to simply limit the amount of sources under consideration.

Another, far less evident, choice was made in order to arrive at a set of sources of workable proportions. As the evolution of script is a very gradual process, not every single year of the period under consideration here needed to be scrutinized. Therefore not all charters produced in our four cities in the period 1300–1550 were taken into account, but, rather, a set of charters assembled at chronological intervals. 'Key years' were chosen every quarter century (1300, 1325, 1350, (…), 1550) and only charters produced in these key years and within a period of five years before or after them were included – yielding a set of 1.818 charters, grouped around 11 key years and written by 602 unique writing hands[17]. (App. 2)

Apart from the practical consideration of keeping the number of sources to manageable proportions, this method of source selection was also motivated by the fact that fundamental changes in writing habits take a few decades to become generally noticeable – prompting the Dutch palaeographer Burgers, for example, to subdivide his summarizing description of the evolution of documentary script in Holland in the thirteenth century in 25-year periods, just

[16] Ibidem, 42; BURGERS, De paleografie van documentaire bronnen, 47–51.

[17] In principle *all* of the locally produced charters originating from within these intervals (1295–1305, 1320–1330, 1345–1355, (…), 1545–1555) and from the archival institutions mentioned above were included in the corpus – unless they are damaged to such an extent that it becomes impossible to firmly date or localize them or would hardly yield any substantial palaeographical information. The charter set used in this article is, however, not exhaustive, as the process of acquiring new charters is still ongoing. See list of sources for an enumeration of the charters used here.

like Karin Schneider did before when discussing German Gothic book scripts from the same epoch[18].

To be sure, scriptural evolution is usually not so clear-cut as to show a fundamental change every 25 years and one should be careful with forcing such a complex process into such an artificial mold. Nevertheless, common sense dictates that, apart from personal variations in handwriting, the possibility that handwriting produced by scribes from different generations will differ fundamentally is bigger, *ceteris paribus*, than handwriting of scribes belonging to the same generation. Studying the development of writing in a 250-year period through 11 chronologically separate sample sets (1295–1305, 1320–1330, 1345–1355, (…), 1545–1555) maximizes the change of identifying these 'generational' developments in writing. It is, of course, perfectly possible for one scribe to be in the same post for many decades[19], as it is for a scribe of 70 years old to work together with a colleague of 25, but that doesn't nullify that fact that the scribes in our 11 sample sets are on average about a generation apart from those in the previous or the next one. Furthermore, even if a scribe is active for many decades his hand will accord itself to some extent to the general trend. It can be quite misleading to think of a writing hand as something completely fixed, like a fingerprint. There certainly are inherently individual characteristics to someone's handwriting, and the more informal the script type the more manifest these individual traits are: this is what makes handwriting identification possible. Nevertheless, it has been demonstrated that individual scribal hands evolve and change to a considerable degree as well[20]. There are, in other words, certain features of handwriting which are not fixed, but constantly evolving under surrounding influences.

Status questions: the problem of script types

Although one doesn't have to start completely from scratch, it is hard to begin an investigation into the development of documentary script in the late Middle Ages without first complaining about the lack of relevant research. An exception should be made for the German language area. There are, in the first place, a number of valuable studies that discuss late medieval scribal practices within the chanceries of the Wittelsbach princes of Bavaria[21]. Apart from this there exists a fair amount of miscellaneous case studies, discussing specific

[18] BURGERS, De paleografie van de documentaire bronnen, 423; K. SCHNEIDER, Gotische Schriften in deutscher Sprache I. Vom späten 12. Jahrhundert bis um 1300, 2 vols., Wiesbaden 1987, 5.

[19] See for example hand Ir/Jj from Arnhem, being represented in two consecutive sample sets from this city, while apparently in office as scribe for the Arnhem board of aldermen for several decades. Cf.: GA_2000_6196 (9.11.1523) and GA_2001_1739 (10.02.1505).

[20] See BURGERS, De palaeografie van de documentaire bronnen, 77–99, where several scribes from the chancellery of the count of Holland are followed over several decades, while their hands evolve. On the same topic, the evolution of individual writing hands, albeit of a non-administrative nature, see N. DVERSTORP, Skrivaren och skriften Om skrift- och handskriftproduction i Vadstena kloster, Oslo 2010; IDEM, Evidence for commercial book production in Vadstena Abbey?, in: The Birgittine Experience, Papers of the Birgitta Conference in Stockholm 2011, Stockholm 2013, 323–331.

[21] See, for example, W. VOLKERT, Kanzlei und Rat in Bayern unter Herzog Stephan II. 1331–1375, Munich 1952; B. ETTELT, Kanzleischriftgut, Kanzlei, Rat und Regierungssystem Herzog Ludwigs des Reichen von Bayern-Landshut 1450–1470, mit Studien aus der Zeit Herzogs Heinrichs des Reichen 1430–1450, Munich 1988; J. SPIEGEL, Urkundenwesen, Kanzlei, Rat und Regierungssystem des Pfalzgrafen bei Rhein und Herzogs von Bayern Ruprecht I. (1309–1390), Munich 1990.

palaeographical phenomena or scribal practices in particular German chanceries or cities. For the most part this research is, however valuable, rather limited geographically and chronologically[22]. The most important full length monograph available, not limiting itself to a particular chancery – albeit limited to the collection of a single archival institution – and discussing late medieval documentary script at length and systematically, is still Heinemeyers landmark *Studien zur Geschichte der Gotischen Urkundenschrift*, dating, originally, from the nineteen fifties[23]. Even Heinemeyer, however, was far from enthusiastic about any attempt to trace the history of documentary script in the later Middle Ages, since it shows so much variation that the big picture tends to become obscured. One of the reasons for this is that from the second half of the thirteenth-century characters started to blend together and influence each other's form. Where in the High Middle Ages several script types and letter models existed beside one another, 'so werden diese jetzt stark veränderlich und stärker als früher von den Neigungen ihrer Schreiber abhängig. Nicht Buchstaben, sondern Worte werden nun geschrieben'[24]. This only applies for documentary script however, according to Heinemeyer, one of his claims being that in the late Middle Ages documentary script (*Geschäftsschrift*) and book script turn their back on each other and live separate lives henceforward[25]. Although feeling uncomfortable with the perceived chaos reigning in late medieval documentary script he does provide us with one of very few attempts at a systematic description of its morphological development, accompanying this with illustrative tables containing depictions of different letter forms – or *allographs*, in more modern parlance. Valuable and groundbreaking though his attempt is as a general qualitative description of some major developments in late medieval documentary script encountered in a large collection of charters from the Middle Rhine region, it also lacks a certain methodological clarity. It remains unclear, for example, what the status of his depictions of various letter forms is. Are these letter forms meant to represent certain archetypes or are they, as one suspects, just random examples he encountered in charters chronologically decades apart, while implicitly assuming that these forms somehow represent a general development? This, of course, touches upon an issue crucial for any research into the development of scripts: how to separate coincidental morphological fluctuations inherent to the nature of script from a genuine morphological evolution? How, in other words, to create order from chaos? Thus far research into the development of late medieval documentary script hasn't really solved this problem.

Traditionally, the palaeographer's method of choice to impose order onto the evolution of scripts is to delineate them into types. An eternal problem however is that it is often impossible, with the possible exception of the Lieftinck-system, to clearly and unequivocally

[22] For an exhaustive enumeration of available research literature see the following two authors, and mainly the second: J. SPIEGEL, Vom Trecento I/II Zum Typ A, B, C,…. Ein Versuch zu Terminologie und (computer-) graphischen Darstellung der Urkundenschrift des 14. Jahrhunderts, in: Zeitschrift für bayerische Landesgeschichte 55 Heft 1 (1992), 65–76; pp. 66–67; E. BOŠNJAK, Urkundenpaläographische Untersuchungen zum Übergang vom Spätmittelalter zur Frühen Neuzeit (15. und 16. Jh.), in: AfD 55 (2009), 263–344, pp. 263–279.

[23] See note 2.

[24] HEINEMEYER, Studien, 131.

[25] Ibid.

distinguish these types[26]. This is especially urgent in the case of late medieval and sixteenth-century documentary script, which apparently shows little unity. Not only is there no unified, generally accepted nomenclature which can be applied to it, there is very little agreement on the parameters any nomenclature or typology should be taking into account. Heinemeyer himself suggested, rather cursory, a division into two basic fourteenth-century documentary script types, which he 'eher scherzhaft und in Ermangelung eines treffenderen Ausdruckes'[27] called 'Trecento I' and 'Trecento II' – at the same time, apart from some general remarks, refraining from attempting to bring more order to the, morphologically even more diverse, fifteenth century. The terms Trecento I and II have indeed for a time become household names in German palaeographic literature[28]. There is some justification for this. During the course of the fourteenth-century shifts in documentary script *did*, of course, take place and Heinemeyer correctly identified a number of them. Leaving aside his more fanciful imagery of the aforementioned script types – Trecento I, for example, being described as 'klein und zierlich, leicht und elegant'[29] – he did trace some tangible general developments in the fourteenth century.

Geschäftsschrift, among which the amplification of the stem of long *s* and *f* in the first half of the fourteenth century and the gradual disappearance of this scribal habit in the second, the transition from double compartment *a* to single compartment *a* and the transition from 'atrophied' (verkümmertes) *g*, with a closed tail, to open tail *g*[30]. These developments are, largely, valid even for the corpus of Dutch documents under consideration here. What remains problematic though is his attempt to force these and many other, much vaguer and harder to define, changes into the mold of a transition from one script type to the next. There are simply too many exceptions to the general rule to postulate such a clear distinction. Letter forms and scribal habits gradually evolved and Heinemeyer rightly pointed out a number of those changes but his attempt to treat these general developments as a kind of paradigm shift, whereby one set of essential script characteristics is, after a certain transitional period, replaced by the next, doesn't hold up to scrutiny.

In an attempt to bring more clarity to the issue Joachim Spiegel has tried to narrow down the *essentialia* of the evolution of documentary script in the fourteenth century by taking Heinemeyers 'guiding characters' (Leitbuchstaben) *a* and *g* and adding to this the state of *m*, thus arriving at three criteria by which to order every sample of fourteenth-century

[26] See for a recent discussion of this much debated issue M. STANSBURY, The computer and the classification of script, in: Kodikologie und Paläographie im digitalen Zeitalter – Codicology and Palaeography in the Digital Age, ed. F. FISCHER et al. (Schriften des Instituts für Dokumentologie und Editorik 2), Norderstedt 2009, 237–249. See for the 'Lieftinck-system' G. I. LIEFTINCK, Pour une nomenclature des écritures livresques de la periode dite gothique, essay s'appliquant specialement aux manuscrits originaires des Pays-Bas medievaux in: Nomenclature des écritures livresques du IXe au XVIe siecle, ed. B. BISCHOFF, G. I. LIEFTINCK, G. BATTELLI, Paris 1954, 15–34. The system is most succinctly explained by P. GUMBERT in: Die Utrechter Kartäuser und ihre Bücher im frühen fünfzehnten Jahrhundert (Teildruck), Leiden 1972, 203–206, and, by the same author, in: Manuscrits datés conservés dans les Pays-Bas. Catalogue paléographique des manuscrits en écriture latine portant des indications de date, T. 2: Les manuscrits d'origine néerlandaise (XIVe–XVIe siècles), et supplément au tome premier [CMD-NL 2], 2 vols., Leiden etc. 1988, 23–31.

[27] HEINEMEYER, Studien, 145.

[28] Cf. SPIEGEL, Vom Trecento I/II, 67.

[29] HEINEMEYER, Studien, 144.

[30] Ibidem, 144–145.

documentary script,: single or double compartment *a*, closed or open tail *g*, and *m* with low arcs – starting at the bottom of the preceding minim – or with high arcs, starting at or near the tip of the preceding minim (see Illus. 1). By means of the same 'cartesian' principles J. P. Gumbert used in constructing his well-known 'cube', one hence obtains eight possible combinations – albeit, of course, that Spiegel's criteria differ notably from the ones used by Gumbert[31]. (App. 3)

Vis-à-vis the corpus of charters in our corpus this thought-provoking approach raises two questions. Do the specific criteria make sense? And: does the ordering principle make sense? To start with the first question: the criteria used by Spiegel seem flawed when applied to our corpus. In our collection of charters low arc *m* and high arc *m* don't show a meaningful chronological distribution or a clear evolution one way or the other. During the entire period under investigation our scribes are just about as likely to use the low arc as the high arc variety of *m*. In other words, these two variant shapes of *m* belong more to the personal domain of writing than to the collective domain. They characterize the writing of an individual, not that of a timeframe or that of some specific collective. Comparable objections, to a lesser extent, could be made against using a binary delineation of *g*, closed or open tailed, as a guiding criterion. The character *g* does show a remarkably datable evolution, different variant shapes collectively coming in and out of fashion. In the first half of the fourteenth century allographs of *g* with a closed tail are indeed used almost exclusively, afterwards gradually being replaced by other varieties, which themselves are in turn replaced. Reducing *g* to two basic shapes seems rather artificial and what is more: a missed opportunity. Rather than forcing the different varieties of *g* into two casts one would do better to use its complete evolution as a guiding datable element[32].

The final criterion, single or double compartment *a*, is the least objectionable and has long been recognized as a watershed in the history of Gothic script. There are other morphological elements of *a* one could be taking into account, but the basic distinction between single or double compartment is most clear cut and seems less artificial then the other criteria used by Spiegel. Nevertheless, although the general evolution of *a* is indisputable – double *a* being replaced by single *a* in the course of the fourteenth century – the way this occurs is less clear and distinct than one would wish it to be. In our corpus single *a* occurs from the very beginning of the fourteenth century, existing alongside double *a* for more than half a century – single compartment *a* not becoming dominant until around 1375. Apart from this, there also exists an 'intermediate' form of *a*, with the second stroke of the letter forming an elongated curve overhanging the basic compartment without really forming a second compartment by itself[33].

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[31] SPIEGEL, Vom Trecento I/II, 72; J. P. GUMBERT, A proposal for a Cartesian nomenclature, in: Essays presented to G.I. Lieftinck, IV: miniatures, scripts, collections (Litterae Textuales), ed. J. P. GUMBERT and M. J. M. DE HAAN, Amsterdam 1976, 45–52. See also, by the same author: CMD-NL 2, 23–31. Gumbert of course based himself on Lieftinck's system, although he, significantly, leaves out the criterion pertaining to the shape of *g*, much elaborated upon by Lieftinck. See LIEFTINCK, Pour une nomenclature, 15–34.

[32] As has recently been done by BURGERS, Palaeography and diplomatics, 22.

[33] See for example several charters from Arnhem: GA_2003_368.14 (16.08.1299) and GA_2003_368.262 (29.06.1325).

Despite these complications it might be feasible to retain the distinction between single and double compartment *a* as a guiding principle and even to revert entirely to the three criteria used by Gumbert – originally derived from Lieftinck – to wit: single or double compartment *a*, loops or no loops at the ascenders *b*, *h*, *k*, *l* and descenders or no descenders at long *s* and *f* (App. 4)[34]. These three criteria – naturally giving eight possible combinations – basically function to delineate the three fundamental Gothic script types once devised by Lieftinck: *Littera Gothica textualis* (double *a*; no loops at *b*, *h*, *k*, *l*; no descenders at long *s* and *f*), *Littera Gothica cursiva* (single *a*; loops; descenders) and *Littera Gothica hybrida* (single *a*; no loops; descenders). A recent survey of 384 Dutch charters dating from the late Middle Ages (1300–1500) by Jan Burgers showed that these almost all fall neatly within the Lieftinckian system, at least when making allowance for a fourth category – already distinguished by Gumbert – named *Cursiva A* (double *a*; loops; descenders) and a further 'intermediate' category named *Cursiva A/C* (both single *a* and double *a*; loops; descenders)[35].

There is, however, a drawback, considering that the overwhelming majority of charters fall within the *Cursiva* category, so that the Lieftinck system has little distinctive force when confronted with documentary script. When one lumps *Cursiva A*, *Cursiva A/C* and regular *Cursiva* together – and, after all, the only parameter here is the evolution of a single letter – there are few non-*cursiva* exceptions left. The situation in late medieval Dutch documentary script is just as one-sided as a German palaeographer recently noticed about the charters in her research corpus (1400–1600), of which 95% belonged, in terms of Lieftinck, to the *Cursiva* category[36]. This means that any general conclusions to be drawn from the development of the script in our corpus of charters are less applicable to the development of the other two Lieftinckian script types – *Hybrida* and *Textualis*, which are very meagerly represented in our corpus.

Since nearly all charters are written in some form of *Cursiva* the Lieftinck system as a *dating* tool, furthermore, is of limited utility. It is, of course, entirely possible to add new criteria and further delineate *Cursiva* as defined by Lieftinck-Gumbert, thus giving it more distinctive force. One could pose the question, however, if 'creating' new subtypes of *Cursiva* would really clarify the historical development of writing or rather obscure it by inventing new script models that may never have functioned as such and have no existence outside the mind of the palaeographer.

A more fruitful approach could be to discard the attempt to depict the history of documentary script in the later Middle Ages as a succession of discrete script types or subtypes, characterized by certain rigid criteria, and instead regard it as a continuous development during which few aspects of writing were not subject to change. (App. 4).

As one scholar recently wrote palaeography essentially has two ways of writing the history of script, a 'Linnean' approach that emphasizes classification, defining each script by means of a

[34] See note 26.

[35] J. BURGERS, Palaeography and diplomatics, 20.

[36] BOŠNJAK, Urkundenpaläographische Untersuchungen, 280; to be sure, *Cursiva* was also often employed in manuscripts. In general it's the most employed type of script in the late Middle Ages in Western Europe. In Dutch manuscripts sources in particular however *Hybrida* is *very* often found. In the *CMD-NL II* the hybrida category makes up about 50% of all dated manuscripts of the fifteenth century.

fixed collection of letter forms that is deemed typical, and a 'Darwinian approach, which sees the fundamental questions as explaining the evolution of scripts and their relationships to each other, as well as looking for mechanisms that explain these phenomena'[37]. This 'Darwinian' take is clearly closest to the method followed here.

Method

While evaluating the enormous impact of the arrival of the digital age on the fields of palaeography and codicology, P. Stokes recently made a, now widely used, distinction between two basic new approaches to the science of script: computer-*driven* and computer-*aided* palaeography[38]. This distinction is also relevant with regard to the methods applicable when constructing a 'medieval palaeographical scale' for dating purposes, which is discussed in this article.

By applying machine learning methods and using processed images of the same corpus of dated and localized charters discussed here, S. He of the University of Groningen has shown that it is possible to bypass the human palaeographical eye completely and arrive at fully automated, computer-based estimations of the year in which query documents were written[39]. The assumption here was that style variation can be traced over time using the evolution of 'textural' image features of a fairly large region of interest in the charter – without needing, therefore, any kind of OCR or manual character segmentation. Utilizing several applications which have previously been used in the context of the GIWIS system for automatic writer identification, namely 'Hinge' and 'Fraglets', which calculate a number of general textural features addressing trace curvature, ink blob distribution and ink trace width, this computer-driven dating method, which is still in development, has already proven to be quite promising, with a mean average error of less than three decades[40].

This method (App. 5) can be complemented however with the method presented here (App. 6) which relies in the first place on human instead of digital analysis. Essentially, it is based on something the computer cannot do well enough up to now, which is to *read* handwritten texts, to recognize graphs as expressions of specific letters of the alphabet, combinations of specific letters, abbreviations or punctuation. It is therefore better suited to trace the development of the morphology of script, which still offers the most insightful way for establishing chronological and geographical palaeographical criteria[41].

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[37] STANSBURY, The computer and the classification of script, 246.

[38] P. STOKES, Computer-aided palaeography, 309–338.

[39] S. HE, P. SAMARA, L. SCHOMAKER and J. BURGERS, Towards style-based dating of historical documents, conference paper delivered at 'International conference on frontiers in handwriting recognition', 2014. http://www.ai.rug.nl/~sheng/icfhr2014-toward.pdf.

[40] Ibidem. GIWIS refers to the Groningen Intelligent Writer Identification System, developed by L. SCHOMAKER et al., 2011. For 'Fraglets', see M. BULACU and L. SCHOMAKER, Text-independent writer identification and verification using textural and allographic features, in: Pattern Analysis and Machine Intelligence, IEEE Transactions on, vol. 29, no. 4 (2007), pp. 701–717. For 'Hinge', see A. BRINK, J. SMIT, M. BULACU, and L. SCHOMAKER, Writer identification using directional ink-trace width measurements, in: Pattern Recognition 45, no. 1 (2012), pp. 162–171.

[41] Cf. STOKES, Computer-aided palaeography, 331; DEROLEZ, The Palaeography, 6–7. Attempts to develop software suitable to compare letter shapes, thus marshaling the computer to automatically establish such criteria,

Our method will essentially be based on allographic variation, that is: on the categorization and statistical processing of collectively used letter forms (allographs), and other collectively evolving graphical phenomena which show a datable evolution – the goal being to trace long term trends in allographical usage, both in order to chart the development of late medieval (*cursiva*) script in general and in order to enable new, straightforward ways to date undated material.

Since the concept of *allographs* is rather important, some elaboration is required. What is essential is that an allograph, in the sense intended here, is a collectively used variant shape of a graph (comprising characters, ligatures, abbreviations, interpunction), used by a group of scribes and clearly distinguishable from other variant shapes used by other groups of scribes. When distinguishing one allograph from another, ideally two parallel developments need to be taken into account: one has to do with *ductus*, id est the *number, sequence* and *general direction* of the stroke(s), which constitute(s) a letter form[42], and the other has to do purely with *shape* – that is: the *presence or absence of specific morphological elements*. However, ductus, plays only a minor role in our discussion, since it is in many cases virtually impossible to establish. Furthermore, it is entirely possible that an identical ductus leads to two or more different letter shapes (*metamorphosis*), as it is equally possible that several different ductus lead to the same letter shape (*meta-analysis*), further complicating matters[43]. It has, indeed, been a hotly contested issue whether ductus is a useful descriptive category at all, with some regarding it as absolutely fundamental and some bypassing it completely. Derolez for example considers ductus a 'vague' concept, and contrasts it with his purely morphological method of study, focusing on the results, the letter forms[44]. Nevertheless, apart from the phenomena of metamorphosis and meta-analysis, changes in ductus often offer the best explanation for changes in morphology. A change in ductus usually coincides with a fundamental change in shape.

A middle road seems prudent. Each allograph is defined here by some essential shape characteristics and, if necessary, also by a specific ductus, such that all *idiographs* (an individual realization of a character in an individual piece of writing) ideally belong to one and only one allograph – without, of course, forgetting the fact that each written instance of a character is to some extent unique, or even claiming that it is possible for two scribes to produce exactly the same letter shape. In other words, the appearance of a certain instance of a character written by an individual scribe has some characteristics unique to it, which pertain to the scribe's individual handwriting, but it also has characteristics in common with other instances of the same character written by other scribes, which is what makes it fit under the

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have been underway for some time, however. See e.g. A. CIULA, Digital palaeography: using the digital representation of medieval script to support palaeographic analysis, in: Digital Medievalist 1 (2005); IDEM, The palaeographical method under the light of a digital approach, in: Kodikologie und Paläographie im digitalen Zeitalter – Codicology and Palaeography in the Digital Age, ed. F. FISCHER et al. (Schriften des Instituts für Dokumentologie und Editorik 2), Norderstedt 2009, 219–235.

[42] Cf. J. MALLON, Paléographie romaine, Madrid 1952, 22. This is identical with what Gumbert calls 'structure': Die Utrechter Kartäuser und ihre Bücher im frühen fünfzehnten Jahrhundert, Leiden 1974, 216–17, n. 7.

[43] The terms *metamorphosis* and *meta-analysis*, used in this sense, are Gumbert's: ibidem.

[44] DEROLEZ, The palaeography, 6–7. The same goes for P. STOKES, English Vernacular Miniscule from Aethelred to Cnut. Circa 990–circa 1035, Cambridge 2014, 3–4.

umbrella of a certain allograph. An allograph consists, in other words, of the set of all idiographs with certain characteristics in common.

That being said, distinguishing allographs can never be an exact science, and not only because often it is exceedingly difficult to clearly, distinctly and objectively draw the line between different letter variations. A more fundamental problem undermining objectivity is that the process of defining and describing allographs always requires the subjective input of the palaeographer, who applies his own judgment and experience in the process. Although methods have been proposed to statistically, and thus more or less objectively, estimate the distinctiveness of a number of a priori determined features of graphs and allographs as encountered in a given set of hands, it still remains for the palaeographer to decide which allographs and graph features to distinguish in the first place, before they can even begin to be statistically processed[45]. In other words, a certain subjectivity is unavoidable, as allographs don't have an existence independent of the observer, but need to be constructed as it were, or at the very least: abstracted. It cannot be ruled – on the long term it is even probable – that improved OCR applications will someday make human palaeographical inspection superfluous even when analyzing the evolution of script. For the time being the palaeographer has to decide which graphic morphological elements, irregularities and developments and which changes in ductus are to be considered meaningful and important, part of a collective development, and which aren't, that is: part of the natural interpersonal variation inherent to script.

Here I will limit my analysis to seven phenomena, namely the development of, *a*, *d*, *g*, *p*, *x*, *g-e* ligature and tongued *e*. Where *a*, *x*, *g-e* ligature and tongued *e***,** will be analyzed in binary terms – *a* and *x* by means of a division into two basic types, and tongued *e* and *g-e* ligature in terms of occurrence or non-occurrence – *d*, *g* and *p* will be handled using a limited catalogue of allographs. (App. 7)

In all cases we will use the same set of 602 charters, corresponding with 602 unique writing hands/scribes. In the many cases where one writing hand was represented by more than one charter in the corpus, only one of these charters was selected – as a rule: chronologically the first one – such that the same exact charter set was used consistently. The number of scribes in this set that use a certain allograph was then counted and charted by key year (1300, 1325, 1350, (…), 1550). When two or more allographical types of the same letter occur simultaneously in one of the charters, which happens often in the case of *p*, *d*, *g* and *a*, they were all regarded as 'occurring' – the total number of occurrences of different allographs of the same letter in a given key year often being much higher than the total number of hands from that key year. The opposite is, of course, also possible. The letter *x*, for example, is often not used at all in a charter, especially not in those written in Dutch.

No attempt was made, furthermore, to count each idiograph of each allograph in each charter of the reference set – which would be statistically ideal, but practically unfeasible. Majuscules were, moreover, excluded. This is especially relevant in the case of *a*, whose double

[45] L. NOGA et al., Estimating the distinctiveness of graphemes and allographs in palaeographic classification, unpublished conference paper *Digital humanities 2012*.

http://www.dh2012.uni-hamburg.de/conference/programme/abstracts/estimating-the-distinctiveness-of-graphemes-and-allographs-in-palaeographic-classification/

compartment type continued its existence as a majuscule even when going out of fashion as the type of *a* in regular usage. This means that, in practice, the shape of *a* was ignored when occurring in first position.

Results: a and x, ge ligature and tongued e

We will start by looking at the development of *a*. As discussed before *a* shows a clearly datable evolution – double *a* being replaced by single *a* from the second half of the fourteenth century onwards. Both double *a* and single *a* can be further divided into certain subtypes (Illus. 5). The subtypes of double *a* don't show a meaningful chronological distribution however, as all of them are used more or less interchangeably. Their geographical distribution does show a certain peculiarity however. It is striking, for example, that most scribes from Louvain writing in the first half of the fourteenth century seem to prefer type 1c. (App. 8)

Single *a* can likewise be divided into a number of subtypes, with type 2a, mostly having a clearly visible two-stroke ductus, being characterized by a straight stem, a pointed top and a gently curving belly. This type occurs from the beginning of the fourteenth century but is soon, from key year 1375 onwards, joined – but not replaced – by type 2b, which is characterized by an angular shape and a ductus in three or four strokes. Much later, from the second half of the fifteenth century onwards, some scribes start to form *a* with a 'broken' stem (2c) while in the first half of the sixteenth century the belly tends to move away from the lower part of this broken stem (2d)[46].

Although this shows that there is in fact a clearly datable evolution of single *a*, there is too much ambiguity and overlap between these subtypes to quantify their occurrence in a satisfactory way. In terms of quantification therefore we will lump these subtypes together into the aforementioned two basic types. (App. 9) Quite predictably the chart shows a strong general decline of the use of double *a* in the course of the fourteenth century. What may surprise however is that the first quarter of the fourteenth century shows an increase, rather than a decline, in the use of this allograph**.** This is caused by the fact that a fairly large number of Arnhem scribes, although still a minority, already use a combination of both double and single *a* around 1300, where a much smaller percentage of their colleagues from the next generation do so, which shows that – although the long term trend is quite clear – the development of allographic usage is often far from being linear.

The example of the Arnhem scribes using a combination of both basic types of *a* very early on also suggests that the geographical spread of habits concerning allographic choice is rather uneven. What is, in this respect, most striking is that Groningen scribes apparently lag behind the other three cities in adopting single *a*. The first occurrence of this allograph in Groningen wasn't until 1400, while in Louvain for example most scribes already used single *a* around 1350, while some did so *exclusively* – which was much more rare in Leiden and Arnhem[47].

[46] See also BOŠNJAK, who noticed the same development concerning ***a*** in this era: Urkundenpaläographische Untersuchungen, 286–287.

[47] Nevertheless V. VAN CAMP mentions a much earlier example (c. 1305) of a scribe working in the Southern Netherlands (*in casu* Hainault) using single *a* almost exclusively: De oorkonden en de kanselarij van de graven van Henegouwen, Holland en Zeeland. Schriftelijke communicatie tijdens een personele unie 1280–1345, 2 vols., Hilversum 2011, 1, 67–68.

Moving on to *x* we can discern a very comparable evolution. Just as is the case with *a* it is possible to divide *x* in a fairly straightforward manner into two basic allographical types. (App. 10) The first is characterized by a two-stroke ductus consisting of two separately traced diagonals crossing each other, with the second diagonal always being approached from above. Type 2 is usually traced in one stroke, with the second diagonal always approached from below, even when traced in two strokes[48].

When quantitatively charting the development of their usage a picture emerges that is rather similar to the evolution of scribal preferences concerning the two basic types of *a* (App. 11), type 2 generally replacing type 1 in the course of the fourteenth century.

Looking somewhat closer at the geographical distribution of scribal preferences it is again striking that Groningen lags far behind the other three cities. As is apparent from the table below, it wasn't until 1400 that Groningen scribes started to use the second, more 'modern' type. In Arnhem, Leiden and Louvain this type was already in use by scribes working around 1350 – with four scribes from Louvain using it around that year, four from Arnhem and one from Leiden – which in the case of Louvain comes down to almost half of the writing hands represented in the corpus at this point in time. This seems to suggest that scribal habits apparently travelled from South to North. (App. 12)

Apart from *a* and *x* it is of course possible to extend the same quantitative analysis to any other palaeographical phenomenon. In this case the occurrence or non-occurrence of 'tongued *e*', and *g*-*e*-ligature (App. 13), will serve as examples. Tongued *e*, observable only when *e* is written in the final position of a word, and noticed to be in general use in documentary sources in Holland from the middle of the thirteenth century onwards, was already in decline in the beginning of the fourteenth century[49]. In our corpus of charters this decline continued unabatedly during the course of that century. (App. 14)

Moving on to *g*-*e* ligature it should first be remarked that a quite strict definition of ligature was applied here, as a single stroke forming a component part of two consecutive characters, thereby influences the shape of both. *Cursiva* script in general abounds in all kinds of ligatures, and the less careful the execution, the more ligatures one finds. Ligatures apparently fulfill some need for efficiency. *G*-*e* ligatures are comparatively rare however and form a later fifteenth-century development. (App. 15)

Results: g, d and p

Although the previous section showed a clear datable evolution of the shape of *a* and *x*, and changing habits over time in the usage of tongued *e* and *g*-*e* ligature, this still leaves us with a rather crude dating tool. An approach to dating based on the shape or presence of these phenomena alone will lack sufficient precision, the kind of precision the evolution of *d*, but mainly *p* and *g* (App. 18 and App. 16/App. 17) does offer – especially when combining these elements. It should be clear that when encountering, for example, *p* type 6 and *g* type 12, it is highly probable that the document they were found in wasn't written before 1500. On the other hand, it is highly likely that a document was written before 1350 when encountering, for

[48] Cf. DEROLEZ, The Paleography, 153.
[49] BURGERS, The palaeography, 27.

example, *g* type 1, *p* type 1 and *d* type 1 simultaneously. When even more characters and palaeographical phenomena are taken into account, the accuracy of the palaeographical scale will continue to increase.

Conclusions

When constructing a 'medieval palaeographical scale' that could be used both to date both undated late medieval documents *and* manuscripts it is necessary to turn to administrative sources, and mainly charters, as they are available in uniquely large quantities and are generally localizable. Acknowledging this, this article outlined how to assemble and evaluate a dated and localized reference set of late medieval charters (1300–1550), which could subsequently be used as a benchmark when tracing the chronological development and geographical spread of any number of late medieval palaeographical phenomena. Although the development of only a limited number of these phenomena was taken into account, it is quite clear that changes in scribal preferences and developments in the morphology of what was written show a clearly datable evolution. A certain geographical pattern in which scribal innovations spread in the area under consideration, which seem to have travelled, broadly, from South to North, also presented itself.

Many challenges remain however. In the first place, more aspects of the development of script than could be discussed here need to be scrutinized. Second, the reference set of documents which was presented here needs to be expanded, both in terms of pure numbers as in localities represented, in order to give the paleographical scale it constitutes more substance. Third, the dating procedure needs to be refined. In this article only a broad indication was given on how the chronological development of the frequency of occurrence of allographical types could be harnessed in order to date undated sources. It is clear, however, that much can be won by using a statistically more refined approach, and a Bayesian statistical scheme in particular – which seems to be eminently suitable for the approach chosen here.

Appendices

App. 1

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App. 2

	Leiden		Arnhem		Louvain		Groningen		Total	
	charters	scribes	Charters	Scribes	Charters	scribes	Charters	Scribes	charters	scribes
1300	2	1	72	28	21	4	2	2	97	35
1325	5	5	115	32	20	3	3	1	143	41
1350	37	9	23	16	16	9	13	5	89	39
1375	103	29	30	16	22	6	19	8	174	59
1400	106	35	52	13	13	8	59	9	230	65
1425	73	14	72	23	14	11	79	22	238	70
1450	115	15	77	15	17	13	43	9	252	52
1475	79	17	38	18	28	25	61	19	206	79
1500	44	16	36	19	14	10	51	14	145	59
1525	45	11	27	17	14	9	42	16	128	53
1550	37	12	41	19	7	5	31	14	116	50
Scribes		164		216		103		119		602
Charters	646		583		186		403		1818	

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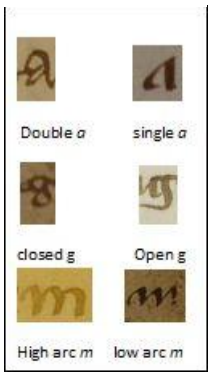
App. 3



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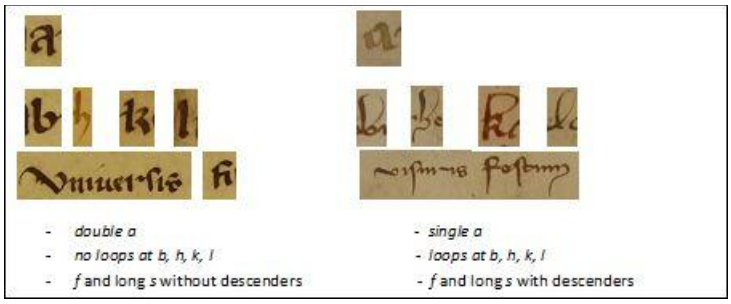
App. 4



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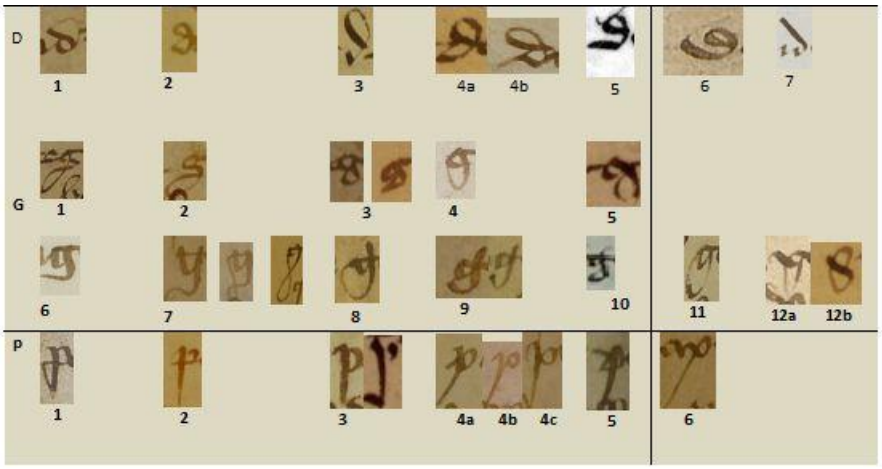
App. 5

Back to Text

App. 6

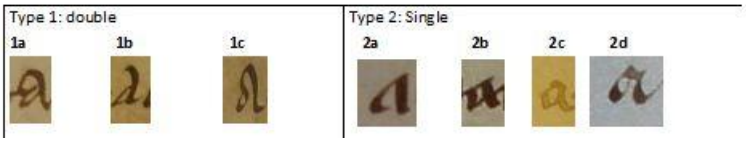
Back to text

App. 7



Back to text

App. 8



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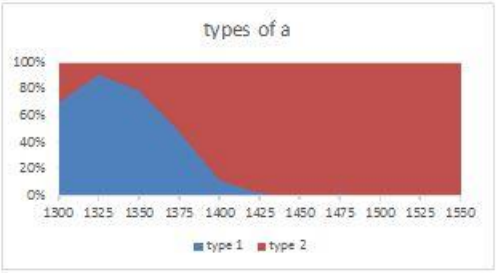
App. 9

9a



9b

A	1300	1325	1350	1375	1400	1425	1450	1475	1500	1525	1550
type 1	37	40	34	32	8	1	0	1	0	0	0
type 2	16	4	9	35	60	70	52	78	59	53	50
Occ	53	44	43	67	68	71	52	79	59	53	50
Hands	35	41	39	59	65	70	52	79	59	53	50

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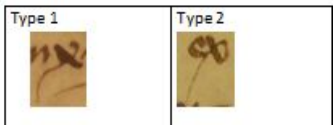
App. 10



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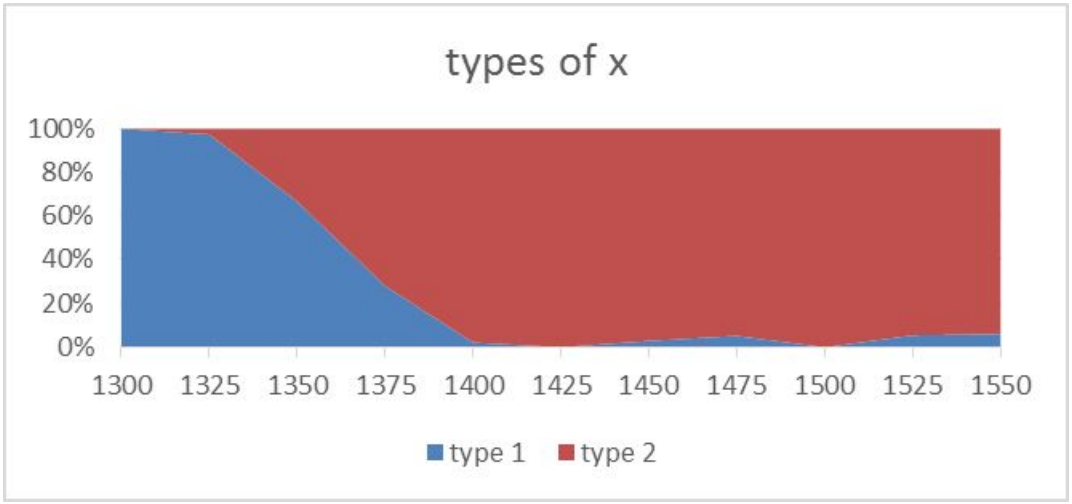
App. 11

11a



11b

X	1300	1325	1350	1375	1400	1425	1450	1475	1500	1525	1550
type 1	36	38	18	7	1	0	1	3	0	2	2
type 2	0	1	9	18	46	32	34	55	46	35	31
Occ	36	39	27	25	47	32	35	58	46	37	33
Hands	35	41	39	59	65	70	52	79	59	53	50

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App. 12

x type 2	1300	1325	1350	1375	1400
Lv	0	0	4	5	9
Ld	0	1	1	3	27
Ar	0	0	4	10	5
Gr	0	0	0	0	5

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App. 13

Tongued *e* as in 'Henrik*e*' and 'd*e*'.	*g-e*-ligature, as in 'g*e*le'.
	

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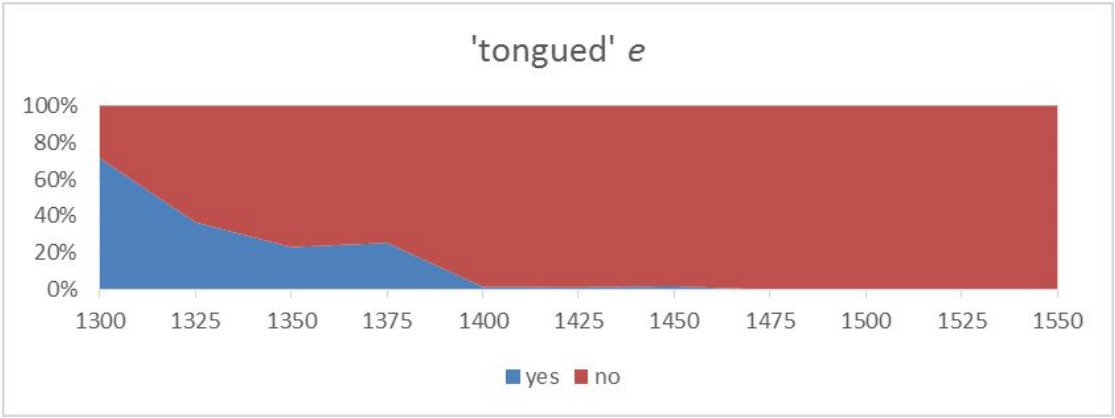
App. 14

14a



14b

tongued e	1300	1325	1350	1375	1400	1425	1450	1475	1500	1525	1550
yes	25	15	9	15	1	1	1	0	0	0	0
no	10	26	30	44	64	69	51	79	59	53	50
occ	35	41	39	59	65	70	52	79	59	53	50
hands	35	41	39	59	65	70	52	79	59	53	50

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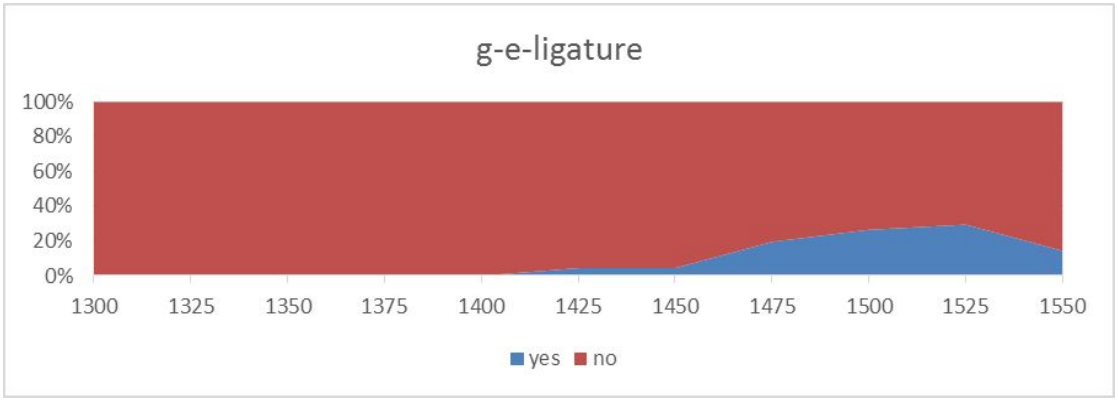
App. 15

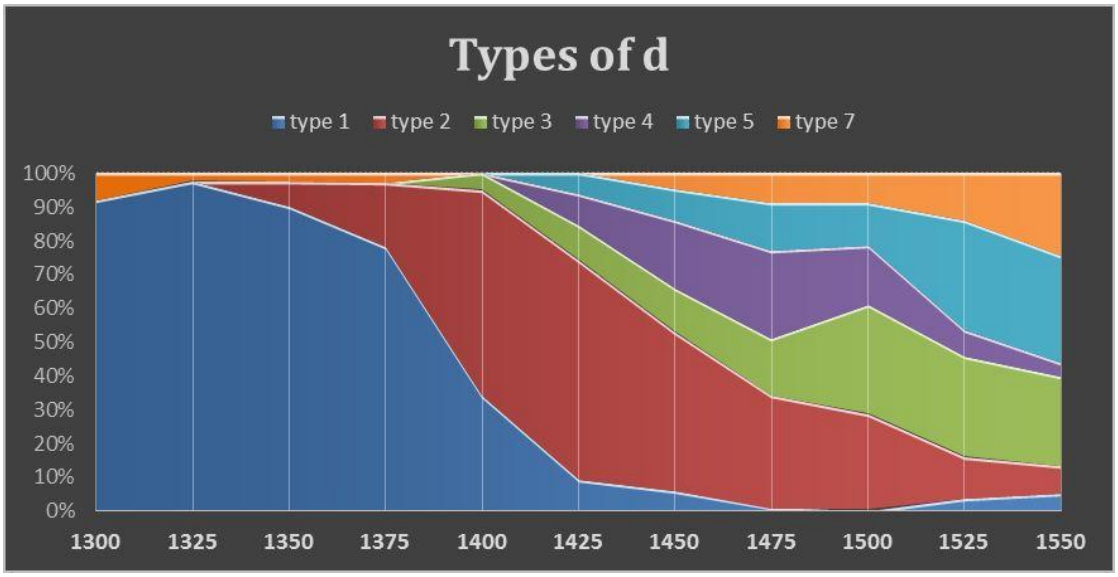
15a



15b

g-e ligature	1300	1325	1350	1375	1400	1425	1450	1475	1500	1525	1550
Yes	0	0	0	0	0	3	2	14	14	15	7
No	35	41	37	59	65	66	44	58	39	36	42
Occ	35	41	37	59	65	69	46	72	53	51	49
Hands	35	41	39	59	65	70	52	79	59	53	50

15c



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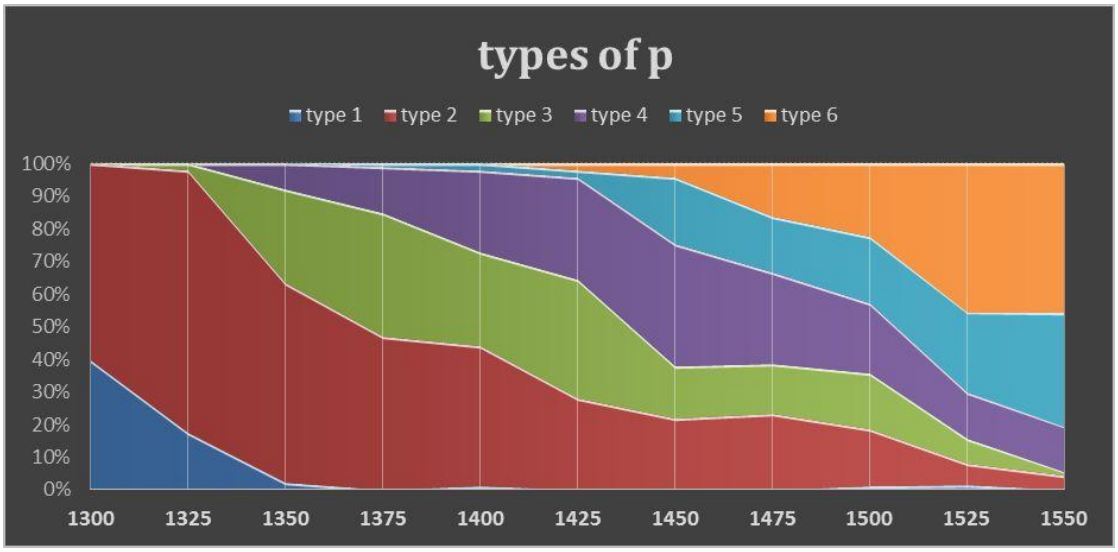
App. 16



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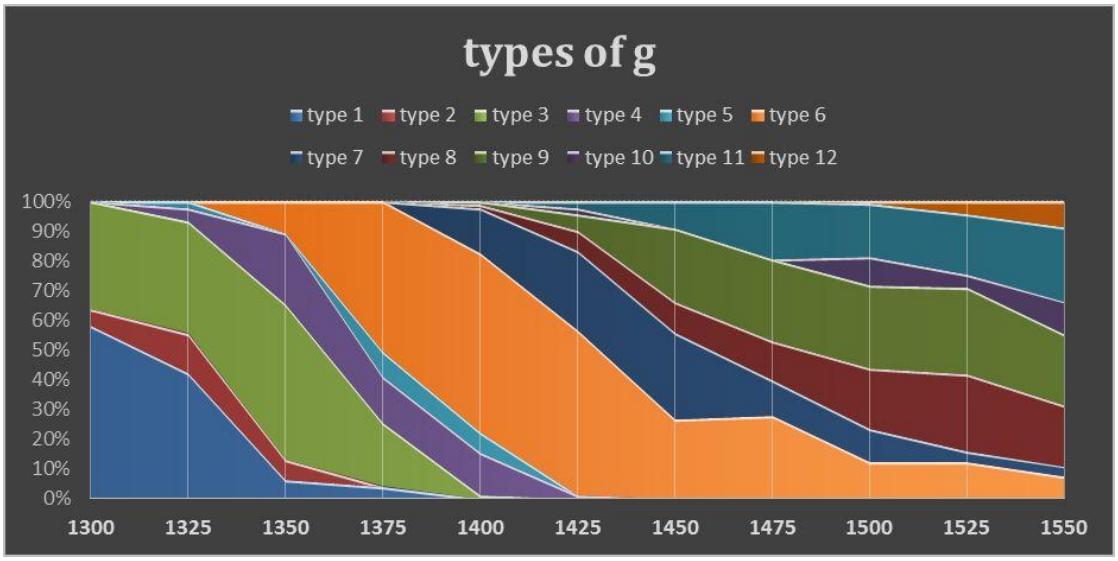
App. 17



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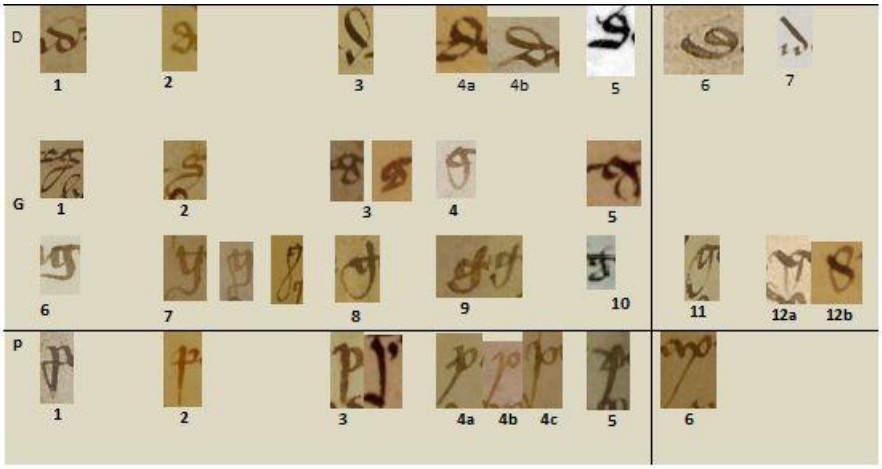
App. 18



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type 1	34	41	37	54	28	9	5	2	1	4	5
type 2	0	0	3	13	50	63	40	51	35	13	8
type 3	0	0	0	0	4	10	11	26	40	31	26
type 4	0	0	0	0	0	9	17	40	22	8	4
type 5	0	0	0	0	0	6	8	22	16	34	31
type 6	0	0	0	0	0	0	7	12	20	21	18
type 7	3	1	1	2	0	0	4	14	11	15	24
occ	37	42	41	69	82	97	92	167	145	126	116
hands	35	41	39	59	65	70	52	79	59	53	50

p	1300	1325	1350	1375	1400	1425	1450	1475	1500	1525	1550
type 1	19	8	1	0	1	0	0	0	1	1	0
type 2	29	37	30	37	39	25	15	27	16	5	3
type 3	0	1	14	30	26	33	11	18	16	6	1
type 4	0	0	4	11	23	28	26	33	20	11	10
type 5	0	0	0	1	2	2	14	20	19	19	25
type 6	0	0	0	0	0	2	3	19	21	35	33
occ	48	46	49	79	91	90	69	117	93	77	72
hands	35	41	39	59	65	70	52	79	59	53	50

g	1300	1325	1350	1375	1400	1425	1450	1475	1500	1525	1550
type 1	21	19	3	3	0	0	0	0	0	0	0
type 2	2	6	3	0	0	0	0	0	0	0	0
type 3	13	17	24	15	1	0	0	1	0	0	0
type 4	0	2	11	11	12	1	0	0	0	0	0
type 5	0	1	0	6	6	0	0	0	0	0	0
type 6	0	0	5	36	51	50	23	36	15	11	7
type 7	0	0	0	0	13	24	25	16	14	3	3
type 8	0	0	0	0	1	6	9	18	25	23	19
type 9	0	0	0	0	1	5	21	37	34	26	22
type 10	0	0	0	0	0	2	0	0	12	4	10
type 11	0	0	0	0	0	2	8	26	22	18	23
type 12	0	0	0	0	0	0	0	0	1	4	8
occ	36	45	46	71	85	90	86	134	123	89	92
hands	35	41	39	59	65	70	52	79	59	53	50

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