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The Speculum Scribe's copy of the Middle Dutch translation of the four gospels

A computational comparison of VIENNA, ÖNB,
SN, 12.857 and its potential exemplars

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Abstract

The purpose of this master's thesis is to reveal if the Speculum Scribe used both Saint Petersburg, BAN, O 256 and Brussels, KBR, 2979 as an exemplar when he constructed Vienna, ÖNB, SN 12.857. These three manuscripts all contain the complete Middle Dutch translation of the four gospels. In previous research, Kwakkel (2002) manually compared specific lines from the three manuscripts (pp. 48-51), while Vandyck, Haverals, and Kestemont (2024a) computationally analysed mean abbreviations densities and plotted bag-of-words models for their corpus, which included these three codices. The current research will perform an in-depth analysis based on concepts from the field of scribal profiling in order to develop a more detailed understanding of the relationship between these manuscripts. The corpus consists of automatic transcriptions created by HTR-models; the model used for the Saint Petersburg manuscript was trained specifically for this research. Distinctive linguistic traits of the manuscripts will be uncovered and the orthographic variation between the Viennese manuscript and its potential exemplars will be diachronically analysed. These computational methods revealed that the Speculum Scribe likely used the Saint Petersburg and Brussels manuscripts as exemplars, although this can only be said with confidence for certain segments of the texts, specifically the gospels of Matthew and Mark for the Saint Petersburg manuscript, but only the gospel of Mark for the Brussels manuscript. Additionally, a number of specific linguistic traits of the Speculum Scribe could be identified.

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All the necessary code and data is available on GitHub: <https://github.com/Anouck-K/Masters-Thesis-Kuypers>.

1. Introduction

The Middle Dutch translation of the four gospels is renowned among medievalists as it is the oldest Middle Dutch prose text to which we have access, as well as one of only two prose texts translated from Latin to Middle Dutch before 1300 (Coun 2015, p. 58). Yet, (surviving) manuscripts that actually contain the translated gospels in their entirety are exceedingly rare. Currently, only three codices have been discovered: VIENNA, ÖNB, SN 12.857, BRUSSELS, KBR, 2979 and SAINT PETERSBURG, BAN, O 256 (Coun 2015, pp. 58-59). The youngest of these is the Viennese manuscript, which has been the subject of much debate. Multiple hypotheses have been formed regarding the manuscript, which suggest that VIENNA, ÖNB, SN 12.857 was either based on only SAINT PETERSBURG, KBR, 2979 or on the Brussels manuscript as well (Kwakkel 1999; Kwakkel 2002 Vandyck, Haverals, and Kestemont 2024a). What follows will be an in-depth analysis of the relationship between these manuscripts. Specifically, the central focus of this master's thesis is to determine if the Speculum Scribe utilised both SAINT PETERSBURG, BAN, O 256 and BRUSSELS, KBR, 2979 as exemplars when constructing VIENNA, ÖNB, SN 12.857 through computational analyses of the (dis)similarities between the three manuscripts and their respective scribal profiles. If the analyses support the hypothesis that the Speculum Scribe did use both exemplars, they could in turn reveal how he copied from them. To start, the subject of research will be contextualised in time and space, after which the content and construction of the manuscripts will be further explored. The methodology used in this research is based on methods and concepts from the field of scribal profiling. After outlining the data collection and preparation in detail, three specific computational methods will be applied. To clarify, these methods will each be performed twice because the Saint Petersburg and Brussels manuscript will be consecutively compared to the Viennese manuscript. A Random Tree Classifier and Burrows' Zeta will be applied to uncover distinctive linguistic traits for both manuscript comparisons. Additionally, diachronic trends will be plotted for both manuscript pairs. To conclude, the results of these analyses, and their implications, will be discussed.

2. Contextualisation and subject of research

2.1 The Carthusian monastery of Herne and the Speculum Scribe

Before delving into the research proper, some necessary terminology needs to be clarified, starting with the term 'production unit'. It was coined by Kwakkel and refers to a set of quires written in one go by one or multiple hands. Accordingly, a codex can consist of one or multiple production units (Kwakkel, 2002, p. 4; Vandyck, Haverals, and Kestemont, 2024a, p. 8). During the production process of these units, scribes often utilised 'exemplars'. These are the codices that served as an example for the scribes so they could create a copied manuscript (Vis et al. n.d.b). As a result, monasteries required one or multiple copies of a text for scribes to use as reference. Two or more copies of the same text are referred to as 'doublets' (Kwakkel 2002, p. 47).

The relevant manuscripts for this thesis are all connected to the Carthusian monastery of Herne, which was founded in 1314 (Neuens 2014, p. 24). The monastery

is renowned among medievalists for producing a strikingly large quantity of Middle Dutch and Latin manuscripts. Research by Kwakkel (2003) indicates that, from 1350 to 1400, 13 different scribes locally produced at least 46 production units spread among 13 manuscripts (pp. 200, 211).¹ This was highly unusual for the time, especially when the majority of productions are in the Dutch vernacular (Kwakkel 2002, p. 36). According to Kwakkel (2003), the amount of vernacular manuscripts from Herne far surpassed that of the other religious houses in the region of Brussels (p. 202). Additionally, the monastery's library included a relatively vast collection of codices enriched with corrections by the local scribes, namely nineteen production units spread among eight manuscripts (p. 201). Herne was also known as an active *translatorium*. Not only did the aforementioned corrections include alternative translations in the Dutch vernacular, but large-scale translation efforts took place there as well. A renowned example is the Bible translation of 1360 by the so-called Bible translator of 1360, who translated an additional fifteen works (Kwakkel, 2002, pp. 138-139; Vandyck, Haverals, and Kestemont, 2024b). He is only referred to by a provisional name since the scribes of Herne's monastery all worked in anonymity. While a list of the inhabitants from 1390 exists (Kwakkel 2002, p. 85), and many hypotheses surrounding the scribes' identities have been formed, no definitive identifications have been widely accepted as of yet.

The shockingly high productivity of the local monks correlates to their solitary lifestyle. The Carthusian monastery finds its fundamentals in Guigo's *Consuetudines*; a set of customs based on "simplicity, wisdom and the loneliness of the Holy Father"² (Nevens 2014, p. 23). Consequently, the monks spent most of their time alone in their cells (p. 25) in absolute silence, although they had occasional opportunities to converse with their fellow monks, such as during walks (p. 27) or for two hours every Sunday (Kwakkel 2002, p. 91). Guigo also held the production of books in high regard; making it a central part of the Carthusian Order (p. 91). Hence, the inhabitants of Herne's monastery dedicated around four hours per day to the production of various manuscripts (van Oostrom 2013, p. 223). The monks often collaborated during this process. Different tasks, namely copying, rubricating and correcting, would then be shared between two or more scribes (Kwakkel 2002, p. 120). Due to the importance of silence and isolation, they communicated by writing notes in the margins. These marginalia reveal a rare insight into the production process for researchers (Vandyck, Haverals, and Kestemont 2024a, p. 2). However, one specific scribe was notably active and is of particular interest to this thesis: the Speculum Scribe.

The Speculum Scribe received his provisional name from his most prolific copy: the second part of the Middle Dutch translation of the *Speculum historiale* (Kwakkel 2002, p. 24) and was likely active from at least 1375 to 1400 (p. 47). He created a large oeuvre consisting of at least the following seven codices: BRUSSELS, KBR, 1805-08, BRUSSELS, KBR, 2849-51, BRUSSELS, KBR, 2905-09 (production unit II), BRUSSELS, KBR, 3093-95 (production unit II and part of I), GENT, UB, Ms. 1374, VIENNA, ÖNB,

1 Notably, recent research by Vandyck, Haverals, and Kestemont (2024a) raises the possibility that there were 12 scribes who produced 42 production units from 12 manuscripts. Their observations indicate that VIENNA, ÖNB, SN 65 was likely not produced in Herne. Only corrections and additions in this manuscript can be attributed to a local scribe, specifically the Speculum Scribe. This sheds doubt on Kwakkel's hypothesis that scribe γ was an active scribe from the Herne Charterhouse, seeing as this was the only manuscript attributed to Herne that could corroborate scribe γ 's localisation (p. 23).

2 Own translation.

COD. 13.708, and VIENNA, ÖNB, SN 12.857.³ He also corrected two additional codices and three production units: BRUSSELS, KBR, 2979, SAINT PETERSBURG, BAN, O 256 and PARIS, BM, 920 (production unit II, III and V) (pp. 45-46). This thesis will concern itself in particular with VIENNA, ÖNB, SN 12.857, BRUSSELS, KBR, 2979 and SAINT PETERSBURG, BAN, O 256.

All three manuscripts contain Middle Dutch translations of the four gospels, which is an exemplary occurrence of the aforementioned doublets. While there is no proof that the Brussels and Saint Petersburg manuscript were created by one of Herne's scribes, they were at least present in the monastery's library on account of the Speculum Scribe's corrections (Kwakkel 2002, pp. 117-118). It can therefore be concluded that the Speculum Scribe also read both codices (Vandyck and Kestemont 2024, p. 889).

As mentioned, Herne's scribes often copied from exemplars, which includes the Speculum Scribe. In the final copied manuscript, which in this case refers to VIENNA, ÖNB, SN 12.857, the utilised exemplar(s) can always be recognised to a certain extent (Vis et al. n.d.b). Kwakkel (2002) theorised that the Saint Petersburg manuscript might have been used as an exemplar to create the Viennese manuscript (p. 50), while observations by Vandyck, Haverals, and Kestemont (2024a) suggest that the Speculum Scribe could have utilised both BRUSSELS, KBR, 2979 and SAINT PETERSBURG, BAN, O 256 (pp. 18-19). Accordingly, further research surrounding this topic is required. This master's thesis will attempt to clarify this issue by resolving two main questions. Firstly, did the Speculum Scribe utilise SAINT PETERSBURG, BAN, O 256 and BRUSSELS, KBR, 2979 as exemplars, or only one of them? Secondly, which parts of VIENNA, ÖNB, SN 12.857 were influenced by which exemplar?

2.2 Manuscript descriptions

2.2.1 SAINT PETERSBURG, BAN, O 256.

SAINT PETERSBURG, BAN, O 256 was likely created around 1325 to 1350 and is the oldest retained manuscript that contains the Middle Dutch translation of the four gospels. The origin of the manuscript is unknown (Coun 2015, p. 58), but property marks indicate that it was likely in Rooklooster around 1400 to 1450. Prior to this, the manuscript was in possession of Herne's monastery, considering that the Speculum Scribe made additions to the ten commandments in the bottom margin of f. 151v (Kwakkel 2002, pp. 261-262). A detailed deconstruction of the manuscript's content and the contributions of every identified hand can be found in the table below. Note that the Speculum Scribe is referred to as "α".

³ VIENNA, ÖNB, SN 65 is not included despite its second production unit being attributed to the Speculum Scribe by Kwakkel (2002, p. 47). Vandyck, Haverals, and Kestemont (2024a) proved that this unit was not actually made by the Speculum Scribe. He was only responsible for corrections and additions (p. 23). For the complete analysis see Vandyck, Haverals, and Kestemont, 2024a.

Table 1

Overview of the production units and the present hands in SAINT PETERSBURG, BAN, O 256 (Kwakkel 2002, pp. 260-263).

	PU	content	main hands ⁴	corrections/additions ⁵
SAINT PE- TERS- BURG, BAN, O 256 (ca. 1325-1350)	I	pericope lists	A(4r-8v) B(9r-13v)	A(instructions f. 4v, 8v) C(1400-1450 corrections)
	II	gospel of Matthew	G (14r-67v)	G (heading f. 14r, headers, chapter numbers, rubrication), A (a few corrections), h (corrections and additions), i (corrections)
	III	gospel of Mark	G(f. 68r-102v)	G (heading f. 68r, headers, chapter numbers, rubrication), h (corrections and additions)
	IV	gospel of Luke	A(f. 104r-168r)	α (addition f. 151v), A (corrections), G (headers, likely the heading f. 104r, possibly chapter numbers and rubrication), h (corrections and additions), j (closing line f. 169v)
	V	gospel of John	G(170r-212r)	G (heading f. 170r, headers, likely the rubrication), h (corrections and additions), j (addition f. 175r)

At present, the manuscript is heavily damaged from having lain underneath a leaking gutter in the Academy of Sciences in Saint Petersburg. It became completely frozen and was defrosted by De Vreese after he discovered it in 1910. This resulted in faded text on many of the pages, as well as offset, which is the transfer of text from a page to the opposite one (Vandyck, Haverals, and Kestemont 2024b). Figure 1 shows how severe the damage can be.

⁴ The letters assigned to each hand are based on Kwakkel's (2002) naming conventions. A hand that only appears in a single codex is referred to by a Latin capital letter, such as "A", but if they solely made small contributions the letter is in lowercase, such as 'a'. This alphabetical codename system restarts for each manuscript, so hand A in this table is not the same hand as A in Table 2. However, a Greek letter indicates a hand that does appear in multiple codices (p. 197).

⁵ Library signatures and property marks are not included.

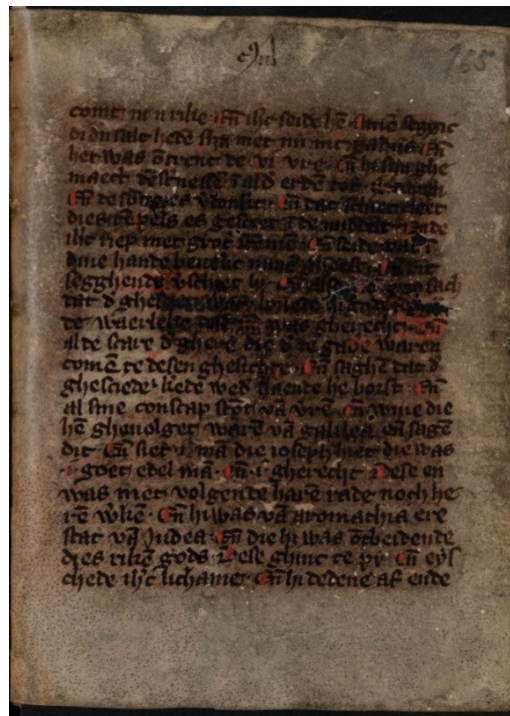


Figure 1
An example of a very damaged page in SAINT PETERSBURG, BAN, O 256 (f. 165r).

2.2.2 BRUSSELS, KBR, 2979.

BRUSSELS, KBR, 2979 is a slightly younger manuscript, dated around 1350. Its scribes wrote the main text in Brabantian Dutch. Therefore, the origin of the Brussels manuscript can be narrowed down to the region of Brabant. Similarly to SAINT PETERSBURG, BAN, O 256, the codex used to be present in Herne, which can be deduced from the presence of multiple corrections and additions by the Speculum Scribe (Kwakkel, 2002, pp. 224-225; Coun, 2015, pp. 58-59). A very interesting alteration by the Speculum Scribe is that, somewhere between 1375 and 1400, he removed the text on folium 58r by scraping it off with a knife and subsequently rewrote it (see Figure 2). This is a technique known as 'erasure' (Kwakkel, 2002, p. 225; Vis et al., n.d.d, p. 8). Afterwards, the manuscript likely ended up in Rooklooster around 1368 to 1373, which is when it received its first property mark of Rooklooster. (Kwakkel 2002, pp. 224-225; Coun 2015, p. 59). Once again, the production units, their content, and the contributions of each scribe are described in the table below. Notably, an error was made during the binding of the quires. Instead of starting the manuscript with the pericope lists, they appear after the first quire of the gospel of Matthew in the second production unit (Kwakkel 2002, p. 224). Table 2 shows the intended order, but the folia numbers remain unchanged.

Table 2

Overview of the production units and the present hands in BRUSSELS, KBR, 2979 ([Kwakkel 2002](#), pp. 224-227).

	PU	content	main hands ⁴	corrections/additions ⁵
BRUSSELS, KBR, 2979 (ca. 1350)	I	pericope lists	A(f. 9r-16v)	α (footer f. 12v, heading f. 13r, additions), several additions/corrections by multiple unknown hands
	II	gospel of Matthew	B (f. 1r-8v, 17r-48v, 50r-57v) C (f. 49r-49v, 58v) α (f. 58r)	B (corrections and additions), α (headers, chapter numbers, large quantity of additions and corrections, likely the rubrication)
	III	gospel of Mark	E (f. 59r-86v)	E (1 correction and 1 addition), α (gloss f. 80v, heading f. 59r, headers, chapter numbers, sporadic additions, likely the rubrication), a few additions by multiple unknown hands
	IV	gospel of Luke	A (f. 87r-134v)	α (heading f. 87r, headers, chapter numbers, sporadic additions, likely the rubrications), g (16th century instruction f. 89r and short rhyme f. 134v), h (15th century addition f. 128v)
	V	gospel of John	A (f. 135r-167r)	A (a few additions and corrections), α (heading f. 135r, headers, chapter numbers, large quantity of additions and corrections, likely the rubrication), h (15th century addition f. 135v, 141v, 145r, 150r), j (15th century folia number f. 167r)

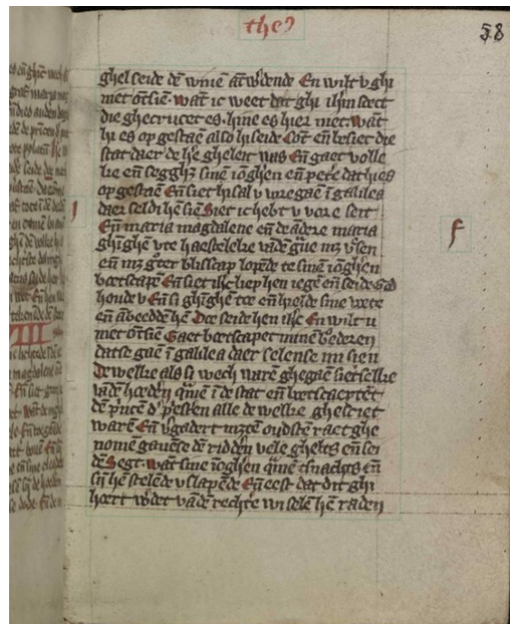
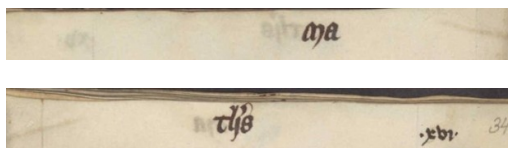


Figure 2
BRUSSELS, KBR, 2979 f. 58r, which was originally by hand C, but later erased and rewritten by the Speculum Scribe.

2.2.3 VIENNA, ÖNB, SN 12.857.

Lastly, VIENNA, ÖNB, SN 12.857 was copied between 1375 and 1400 by the Speculum Scribe, with added corrections and initials by the Necrology Scribe, who was a fellow local scribe (Coun 2015, p. 59). This collaboration confirms that the Viennese manuscript was made in Herne. It is certain that the Necrology Scribe resided in Herne's charterhouse because, among others, he was responsible for the monastery's necrology (Kwakkel 2002, p. 73-76) and his localisation subsequently corroborates that the Speculum Scribe, his close and frequent collaborator, is also from Herne (pp. 59-60).

The Speculum Scribe only wrote the second and fourth production unit of VIENNA, ÖNB, SN 12.857. The other two units were likely added in Rooklooster since their hand is younger than the property sign of Rooklooster (pp. 276-277). Furthermore, VIENNA, ÖNB, SN 12.857 displays the Speculum Scribe's unique way of writing down headers. He would split the header and write one half on the verso side of the left folium and the other half on the recto side of the right folium. For example, the folia in VIENNA, ÖNB, SN 12.857 that contain the gospel of Matthew include *ma | theus* at the top (see figure 3). The headers that he added to BRUSSELS, KBR, 2979, as shown in Table 2, follow this same system (p. 105).

**Figure 3**

Example of the Speculum Scribe's unique header system in VIENNA, ÖNB, SN 12.857 (top: f. 33v, bottom: f. 34r).

Table 3

Overview of the production units and the present hands in VIENNA, ÖNB, 12.857 (Kwakkel 2002, pp. 275-277).

	PU	content	main hands ⁴	corrections/additions ⁵
VIENNA, ÖNB, SN, 12.857	I (1450-1500)	an aid on how one should read the gospels	A (f. 1r-2r)	A (rubrication and one correction)
	II (1375-1400)	first set of pericope lists	α (f. 3r-10r)	α (rubrication and a few corrections), b (addition f. 10r)
	III (ca. 1450)	second set of pericope lists	C (f. 11r-18v)	C (likely the folia numbering of the entire manuscript)
	IV (1375-1400)	Middle Dutch translation of the four gospels	α (f. 19r-240v)	α (headings, corrections and additions, majority of the rubrication), β (initials at the start of chapters, a few chapter numbers, ± 30 translation corrections, comment on translation quality f. 95v), d (ca. 1400 addition f. 210r)

2.2.4 Types of gospel manuscripts.

As displayed in the previous three tables, all three manuscripts are comprised of pericope lists⁶ followed by the Middle Dutch translation of the four gospels. The translation itself is suspected to originate from roughly 1200, making it the oldest piece of surviving Middle Dutch prose (Coun 2015, p. 58).

In 1999, Kwakkel performed a comparative study of different varieties of Middle Dutch gospel translations from the 13th and 14th century (p. 166). He mentions that the gospels can take the shape of a gospel harmony, in which they are written down as one ongoing story (Vis et al. n.d.a), or be non-harmonised. The latter is divided into

⁶ Pericope lists specify which passages (pericopes) from the gospels should be read on which days of the year (Vis et al. n.d.c).

three categories: “codices with an integral translation of the four gospels”, “gospels with gloss” which provide explanations for the pericopes and “a codex with pericopes from the bible ordered by liturgical year” known as a lectionarium (Kwakkel 1999, pp. 171-172)⁷. Lectionaria can also be divided into three subcategories: evangeliarium, epistolarium and plenarium. An evangeliarium contains gospel pericopes, while the pericopes in an epistolarium are from epistles. A plenarium contains pericopes from both epistles and the gospels (p. 172). The Saint Petersburg, Brussels and Viennese manuscript all contain the same integral translation of the four gospels (p. 173), which aligns with the very first type of non-harmonised gospels. However, as mentioned, all three manuscripts also include a table of pericopes that specifies which passages should be read during different moments of the calendar of saints. To clarify, this means that the manuscripts can be used as evangeliaria, while still containing the gospels in their entirety instead of only the necessary pericopes (p. 173).

3. State of the art

In Kwakkel’s (1999) comparative study of varieties of Middle Dutch gospel translations, he states that manuscripts utilising a common source will display more variations as the source becomes older (p. 172). The Middle Dutch translation of the four gospels likely dates back to the middle of the thirteenth century and is possibly the oldest Middle Dutch gospel translation (Kwakkel 2002, p. 48). Consequently, the content of the Saint Petersburg codex displays many lexical and syntactical differences compared to BRUSSELS, KBR, 2979 (Kwakkel 1999, pp. 172-173). On the other hand, the Saint Petersburg and Viennese manuscript are very similar, despite some striking differences. Thus, Kwakkel believes that, when constructing a tree of manuscripts from oldest to most recent, SAINT PETERSBURG, BAN, O 256 and BRUSSELS, KBR, 2979 would belong to different branches (p. 173).

Kwakkel (2002) performs a more in-depth comparison in a section of his Ph.D. thesis, where he directly compares lines from twenty folia of the Viennese codex to the matching lines from the other two codices.⁸ Since the variations between lines are especially egregious when comparing the Viennese and Brussels manuscript, Kwakkel concludes that it is unlikely the Speculum Scribe utilised BRUSSELS, KBR, 2979 as an exemplar for VIENNA, ÖNB, SN 12.857 (p. 49). The latter also occasionally included lines which were not present in the former (pp 50-51). Below are a few lines which he uses to support his hypothesis.

B, f. 2r Herodes dies conincs Siet **meesters** quamen van oriente te Jherusalem ende seiden.

S, f. 15r Herodes dies conincs siet **magi** quamen van orienten te Jhersualem segghende

W, f. 20r Herodes dies conincs siet **magi** quamen van orienten te Jherusalem segghende

B, f. 94v enen onsuveren **geest**

S, f. 115r enen onsuveren **duvel**

W, f. 136r enen onsuveren **duvel**

B, f. 87r in der **ordene** siere **straten**

⁷ Own translation.

⁸ Kwakkel (2002) addresses that a more extensive comparison is necessary to construct a proper stemma (a tree of manuscripts). He mainly wanted to demonstrate that large differences exist between VIENNA, ÖNB, SN, 12.857 and BRUSSELS, KBR, 2979, for which 20 folia sufficed (p. 49).

S, f. 104r in der **ordene** siere **straten**
W, f. 124v in der **ordinancien** siere **behoerten**
(Kwakkel 2002, p. 49)⁹

Moreover, the majority of Kwakkel's (2002) comparisons reveal that the Viennese and Saint-Petersburg manuscript align where Brussels differs, which likely means that the Speculum Scribe did employ the Saint Petersburg manuscript as an exemplar. Kwakkel believes that the few instances where they do not match are possibly caused by the Speculum scribe making alterations, such as for 'ordinancien' and 'behoerten' in the fragment above. However, Kwakkel admits that it is also possible that the Viennese manuscript simply utilised an exemplar which was similar to SAINT PETERSBURG, BAN, O 256. Yet, the only noteworthy difference that could support this possibility, is that corrections added to the Saint-Petersburg manuscript, prior to the creation of VIENNA, ÖNB, SN 12.857, were not incorporated by the Speculum Scribe. This can be seen in the following lines (p. 50).

B, f. 56r setten sise hem op sijn hoeft ende een riet in sine rechte hant
S, f. 64v setten sise op sijn hovet ende [#] i riet in sinen rechte hant [# **gaven hem**]
W, f. 80v setten sise op sijn hovet ende een riet in sinen rechte hant
(Kwakkel 2002, p. 50)

Recent research by Vandyck, Haverals, and Kestemont (2024a) builds on Kwakkel's hypothesis. Kwakkel (2002) believes that the Speculum Scribe only used SAINT PETERSBURG, BAN, O 256 as an exemplar, yet Vandyck, Haverals, and Kestemont (2024a) establish that both BRUSSELS, KBR, 2979 and SAINT PETERSBURG, BAN, O 256 could have served as exemplars. Instead of performing a codicological and paleographic study of the manuscripts produced in Herne from 1350 to 1400, Vandyck, Haverals, and Kestemont (2024a) take a computational approach and focus on the scribes' linguistic traits (p. 4). They specifically studied the scribal variation present in the manuscripts. These variations were caused by a lack of a standard language variety and standardised spelling. Additionally, scribes could purposely alter sections of a texts or make a mistake when copying. While research concerned with authorship deals with scribal variation as an obstacle to overcome, since it obscures the original author's writing, Vandyck, Haverals, and Kestemont (2024a) used it to their advantage to identify the different scribes' "unique fingerprints"; a practice known as "scribal profiling" (p. 6). Naturally, a scribe could be difficult to identify by their linguistic habits if they stick very close to their exemplar. However, this could be resolved through paleographic analyses (p. 7) and subsequently reveal trends in a scribe's copying style, leading to new hypotheses.

Vandyck, Haverals, and Kestemont (2024a) compared the mean abbreviation density for the scribes in their corpus¹⁰ by calculating "the ratio of the total number of brevigraphs to the total number of letter characters in a text" (p. 10). An analysis of the abbreviation density for all of the Speculum Scribe's work revealed that some manuscripts exhibited a lower rate of abbreviations than what was usual for him; among which was VIENNA, ÖNB, SN 12.857 (p. 12). Additionally, a bag-of-words (BOW) model was

9 'B' refers to BRUSSELS, KBR, 2979, 'S' to SAINT PETERSBURG, BAN, O 256 and 'W' to VIENNA, ÖNB, SN 12.857 (Kwakkel 2002, p. 48).

10 This corpus consists of "the majority of Middle Dutch manuscripts linked to Herne during the reference period 1350-1400, as per Kwakkel's library reconstruction", along with "GHENT, UL, 941" because it "bears a close relationship in content to BRUSSELS, KBR, 2877-79 and BRUSSELS, KBR, 2879-80" (Vandyck, Haverals, and Kestemont 2024a, p. 7).

constructed for the hundred most common character bigrams¹¹ that included at least one brevigraph¹². This BOW model is essentially a table where the columns represent the aforementioned character bigrams and each row stands for a separate text. Instead of utilising the absolute bigram counts, Vandyck, Haverals, and Kestemont (2024a) used the term frequency-inverse document frequency (TF-IDF). The higher the frequency of a word is and the lower the amount of documents it appears in, the more significant it will be. To avoid text length from influencing the data, all production-units were divided into “non-overlapping, consecutive segments of 5,000 characters” (pp. 16-17). The resulting scatterplot displayed a clear cluster of the Speculum Scribe’s works, meaning that a distinct copying style was indeed identifiable through computational means. Notably, VIENNA ÖNB SN 12.857 was positioned outside of this cluster. It appeared together “with segments by scribe B from BRUSSELS, KBR, 2979 [...], and SAINT PETERSBURG, BAN, O 256 [...]” (p. 18). Vandyck, Haverals, and Kestemont (2024a) established that this did not simply occur because all three codices contained the same content by repeating their analysis without the Brussels and Saint Petersburg manuscript. In this experiment, VIENNA ÖNB SN 12.857 still did not cluster with the Speculum Scribe’s other works (pp. 18-19). Furthermore, paleographic research confirms that VIENNA ÖNB SN 12.857 was copied by the Speculum Scribe (Kwakkel 2002, p. 48). Thus, Vandyck, Haverals, and Kestemont (2024a) hypothesise that this different copying style in the Viennese manuscript was caused by the Speculum Scribe making a much closer copy of his exemplars than usual. Perhaps this was an early work of his, making him less inclined to stray too far from the source (p. 19). This implies that the Speculum Scribe possibly used SAINT PETERSBURG, BAN, O 256 and BRUSSELS, KBR, 2979 as exemplars. While Vandyck, Haverals, and Kestemont’s findings are very intriguing, additional research is necessary for their theory to be fully accepted.

Vandyck and Kestemont (2024) delved deeper into this unusual clustering and analysed the Speculum Scribe’s abbreviation use (p. 882). Since a scribe deliberately chooses to add an abbreviation, it is a great indicator of their writing style, especially since they appear consistently throughout the manuscripts and are disconnected from the content of the text (p. 885). A boxplot of distinctive abbreviations reveals that “a”, “d̄”, and “gē” appear less often in VIENNA ÖNB, SN, 12.857 compared to the Speculum Scribe’s other manuscripts. This could indicate that he did not yet adopt a more frequent use of these abbreviations when copying VIENNA ÖNB SN 12.857 (pp. 886-887). Additionally, he hardly ever abbreviated “dat” as “d̄” in the Viennese manuscript, while it appears much more often in his other manuscripts. Vandyck and Kestemont (2024) uncovered a clear evolution: the Speculum Scribe “makes a binary jump in his application of the abbreviation [̄], from almost never in the context of *dat*, to almost never in the context of *det*” (pp. 887-888). They believe that he was influenced by BRUSSELS, KBR, 2979, one of the few manuscripts in the Herne corpus that abbreviates “dat” as “d̄”, to incorporate this abbreviation in his future works (p. 889). While this new evidence certainly supports the hypothesis that VIENNA ÖNB, SN, 12.857 is an early production of the Speculum Scribe, it remains uncertain which exemplars he utilised to create this codex.

11 A bigram is a set of two consecutive characters (Vandyck, Haverals, and Kestemont 2024a, p. 17). For example, *gheue* is short for *gheuen* (to give/giving) and *d̄* stands for *dus* (so).

12 Brevigraphs are “handwritten abbreviations which shorten [a] word by specific signs or flourishes [sic]” (Honkapohja and Marcus 2024, p. 45).

4. Methodology

As mentioned, this master's thesis will investigate the relationship between the Viennese manuscript, attributed to the Speculum Scribe, and the Saint Petersburg and Brussels manuscript, his potential exemplars. Similarly to [Vandyck, Haverals, and Kestemont \(2024a\)](#) and [Haverals and Kestemont \(2023a\)](#) the degree of scribal appropriation will be investigated through computational methods and research will be limited to the linguistic characteristics of the texts. Methods related to the field of scribal profiling will prove crucial to identify and interpret both scribal variation and appropriation when comparing the three manuscripts.

[McIntosh \(1975\)](#) states that a scribe's unique, linguistic profile can be constructed from distinctive linguistic traits that appear in texts solely written or copied by that scribe (p.220-221; 223). Even when copying from exemplars, it is common for scribes to incorporate elements from their own style (p. 224). An analysis of the Speculum Scribe's traits in VIENNA, ÖNB, SN 12.857 could reveal how his linguistic style differs from the writing of the exemplars (p. 221). On the other hand, clear similarities between linguistic scribal profiles can indicate when a manuscript was used as an exemplar (p. 231-232).

[McIntosh \(1973\)](#) describes three relationships that can exist between a manuscripts and its exemplar(s). First, the scribe might very closely copy the text of his source, meaning both works exhibit high similarities. Secondly, the scribe might insert an abundance of his own additions or modifications, leading to extreme dissimilarities. Lastly, and most commonly, if the previous two patterns would be assigned to both ends of a scale, a scribe's copying style might situate itself anywhere between these two extremes (p. 61). Naturally, these patterns do not necessarily remain static throughout the entire length of a text. A manuscript might start to more, or less, closely resemble its source as its content progresses, leading to converging, or diverging, movements when directly comparing both texts ([Haverals and Kestemont 2023a](#), pp. 14-15). Moreover, when one scribe uses a source made by two or more scribes, a sudden change in copying style can be detected once the hand in the exemplar switches, as the copying scribe might adopt some of their linguistic traits. Yet, the copying scribe's linguistic profile remains distinct, it will only contain traces of other styles ([McIntosh 1975](#), p. 230).

The Speculum Scribe's distinctive linguistic traits, as well as the unique traits in the Saint Petersburg and Brussels manuscripts, will be computationally identified. As a result the scribal profiles of the manuscripts can be thoroughly compared. Additionally, diachronic trends for both manuscript pairs can form a visual representation of the copying patterns described by [McIntosh](#). [Haverals and Kestemont \(2023a\)](#) conducted a similar comparison of two Hadewijch manuscripts and this thesis will take a similar approach and use their code as a base.¹³

5. Research data

5.1 materials

The corpus consists of SAINT PETERSBURG, BAN, O 256, BRUSSELS, KBR, 2979 and VIENNA, ÖNB, SN 12.857. To properly assess the degree of scribal appropriation present in VIENNA, ÖNB, SN 12.857, the manuscripts need to be compared in their entirety. Manually transcribing all 623 folia would be a vast undertaking, which is why

¹³ This code is freely available on GitHub: <https://github.com/WHaverals/hadewijch-scribes>

Handwritten Text Recognition (HTR) was used to create digital transcriptions of the corpus. Thanks to the *Silent Voices* project by Mike Kestemont, Wouter Haverals and Caroline Vandyck, a general HTR model had already been trained on almost every Middle Dutch manuscript connected to Herne, as well as GHENT,UL,941 and PARIS, BIBL. DE L'ARSENAL, 8224 (Haverals and Kestemont 2023b, p. 137, p. 139).

First, they uploaded photos of these manuscripts in their entirety to *Transkribus* (Haverals and Kestemont 2023b, p. 142), an online platform that allows users to manually transcribe, add metadata and train layout or HTR models in a straightforward manner (READ-COOP SCE n.d.a). The text regions were then manually outlined because an automatic layout model runs the risk of making mistakes due to imperfections on the parchment. The baselines, however, were automatically detected by applying two models trained in *Transkribus*. A specialised model was used for manuscripts with unusual layouts or when they were heavily damaged, such as SAINT PETERSBURG, BAN, O 256, but a general baseline detection model was applied to the majority of the corpus. This general model was trained on 1,007 folia with manually added baselines and “obtained an error rate of 7.00% on the training set [...] and 6.35% on the validation set with 111 folia”. Afterwards, any errors in the baseline recognition for the entire corpus were manually corrected (Haverals and Kestemont 2023b, pp. 142-143).

Haverals and Kestemont (2023b) trained the Grand Middle Dutch Model on hyper-diplomatic, manual transcriptions of their corpus. This entails that the transcriptions are as close to the manuscripts as possible and the spelling and brevigraphs retain their original form (p. 141; pp. 143-144). Letters with multiple written forms were an exception. For example, ‘f’ (the long s) and ‘s’ (the round s) both stand for the letter ‘s’ and would be transcribed as such (p. 143). The original letter forms would only be adhered to when they indicated a distinction in phonetic realisations; specifically ‘u’ or ‘v’ and ‘i’ or ‘j’ (Vandyck, Haverals, and Kestemont 2024a, p. 7). To transcribe the brevigraphs, special characters need to be used. Haverals and Kestemont (2023b) retrieved the corresponding precomposed Unicode characters from the Medieval Unicode Font Initiative (MUFI). This is crucial to ensure that brevigraphs consisting of multiple elements, such as “n̄” (Latin small letter n with medium-high macron), are regarded as only a single character (p. 143).

In accordance with the described guidelines, manual transcriptions were made of, at minimum, 10% of each manuscript. This ensured a fair representation of the entire corpus to avoid bias. Finally, the Grand Middle Dutch Model was trained on a training set of 1,197 folia (ca. 285,000 words) and tested on a validation set of 133 folia (ca. 33,000 words). The final model achieved a Character Error Rate (CER) of 2.7% on the validation set. It could subsequently be applied to the remaining 4,828 folia of the corpus (Haverals and Kestemont 2023b, pp. 143-144).¹⁴

On account of the Grand Middle Dutch Model, digital transcriptions of both BRUSSELS, KBR, 2979, VIENNA, ÖNB, SN 12.857 and SAINT PETERSBURG, BAN, O 256 were available prior to this study. However, the transcription of SAINT PETERSBURG, BAN, O 256 is partially unusable since the manuscript is so heavily damaged. This severely impacted the output of the HTR model, causing many pages to be transcribed as nonsense. A specialised HTR model would be a necessity for this manuscript. The text regions and baselines had already been indicated in *Transkribus* as part of the *Silent Voices* project, moreover, 12 out of 212 folia had been manually transcribed. Under dra. Vandyck’s supervision, I transcribed an additional 34 folia, following the exact same

14 The resulting transcriptions are available on Zenodo: <https://zenodo.org/records/10005366>

transcription guidelines as previously described for *Silent Voices*. In SAINT PETERSBURG, BAN, O 256, three hands are responsible for the main text across all production units (see Table 1). The hands A, B and G respectively wrote down approximately 34%, 2% and 64% of the text. To ensure that the Ground Truth was representative of the entire codex, the selected folia adhered to the same distribution of hands. The proportionate amount of folia for each hand was selected from the folia they copied via a random sample to avoid bias.

Prior to training the model, the Grand Middle Dutch Model was selected as a base model to improve performance, since a Ground Truth of 46 folia is fairly small. The folia were subsequently split into a training set of 38 folia and a validation set of 8 folia. Lines that included unreadable text due to severe damage, or where text was entirely missing, were not taken into consideration during training because it could negatively impact the HTR model's performance.¹⁵ Each side of a folium contains 23 lines Kwakkel (2002, p. 261-263), which means that the training folia contain roughly 1748 transcribed lines, 276 of which included one or multiple "unclear" tags. The model trained on a training set of 38 folia, achieving a CER of 4.20%, while achieving a CER of 4.58% on the validation set of 8 folia. The CER for the validation set indicates that for every 100 words, 4.5 of them will on average be transcribed incorrectly. For a severely damaged manuscript such as SAINT PETERSBURG, BAN, O 256 this is certainly a favourable result. Thus, the HTR model was applied to the remaining 166 folia (see Table 4).

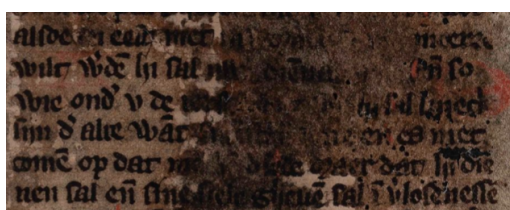


Figure 4

Example of both unreadable and missing text due to offset that was tagged as "unclear".(SAINT PETERSBURG, BAN, O 256, f. 89r.)

Table 4

Overview of the production units and the present hands in VIENNA, ÖNB, 12.857 (Kwakkel 2002, pp. 275-277).

SAINT PETERSBURG, BAN, O 256			
Ground Truth	46 folia		
Remaining	166 folia		
distribution of main text hands ¹⁶			
hands	A	B	G
proportion of folia	0.34	0.02	0.64
specialised model training			
training set	38 folia	10,368 words	4.20 CER
validation set	8 folia	2,665 words	4,58 CER

¹⁵ If one or multiple words are marked as "unclear" in *Transkribus*, the entire line will be excluded during model training when "Omit lines by tag 'unclear' or 'gap'" is selected (READ-COOP SCE n.d.b)

5.2 data preparation¹⁷

During the preprocessing of the diplomatic transcriptions, production units that bear no relevance to the research at hand have been removed. As seen in Table 3, production unit one and three in VIENNA, ÖNB, SN, 12.857 were not made by the Speculum Scribe and are therefore irrelevant. Additionally, the pericope lists vastly differ among all manuscripts and are separate from the gospels themselves which makes them unrelated to the research at hand. Folia that solely contained library signatures or property marks were also excluded from every manuscript. This leaves us with only the transcriptions of the four gospels. The final dataset consists of three plain text files which respectively contain the diplomatic transcriptions of the remaining 226 folia from VIENNA, ÖNB, SN, 12.857, 206 folia from SAINT PETERSBURG, BAN, O 256 and 159 folia from BRUSSELS, KBR, 2979. The same, basic preprocessing was performed on all three files: additional whitespaces were removed and any words which the scribes split among lines with a hyphen were rejoined. If left unaltered, these hyphenated words would be incorrectly labelled as a dissimilarity after aligning the transcriptions. No further changes were made to the raw text.

Regarding the proper alignment of the manuscripts, this thesis opted for two separate pairwise sequence alignments instead of a three-way sequence alignment. This was done to prevent similarities or differences between SAINT PETERSBURG, BAN, O 256 and BRUSSELS, KBR, 2979 from influencing the alignment process and because the current research is not focused on how the Saint Petersburg manuscript compares to the Brussels manuscript. The Needleman-Wunsch algorithm was applied to VIENNA, ÖNB, SN, 12.857 and SAINT PETERSBURG, BAN, O 256 as well as VIENNA, ÖNB, SN, 12.857 and BRUSSELS, KBR, 2979 to create two pairwise sequence alignments at the word-level (Needleman and Wunsch 1970).¹⁸ Both pairwise alignment tables were subsequently split into 85 slices. This entails that each text within these tables was segmented into 85 slices, leading to a total of 170 slices per alignment. Each of these slices consists of roughly 1000 tokens. The reason for aligning the manuscripts before segmenting them, is to ensure that the content of all the segments in a manuscript pair matches. Simply selecting a set amount of sentences would result in a mismatch between the sequences since the manuscripts are not identical. Furthermore, these sliced alignments will be essential for researching diachronic trends in section 6.2. The tables below partially display one of these aligned slices.

¹⁶ Not every folia includes text on both sides, which was taken into account when calculating the distribution of hands

¹⁷ All of the code for the data preparation as well as the analyses in section 6 can be downloaded from the following GitHub repository: <https://github.com/Anouck-K/Masters-Thesis-Kuypers/tree/main>

¹⁸ Due to computational restraints, the plain text files had to first be divided into eight chunks with matching, manually selected boundaries. The matching chunks were then aligned for both manuscript pairs, after which they were recombined to form the fully aligned texts mentioned here. Similarly to (Haverals and Kestemont 2023a), the Python library by Folger Karsdorp was used to apply the Needleman-Wunsch algorithm to the manuscripts, which can be downloaded here: <https://github.com/fbkarsdorp/alignment>

Table 5

The beginning of slice 48 for both manuscripts of the Viennese (V) and Saint Petersburg (SP) alignment.

V	noch	ē	setse	ōd'	.i.	bedde	.
SP	noch	en	setse	ond'	.i.	bedde	.

Table 6

The beginning of slice 48 for both manuscripts of the Viennese (V) and Brussels (B) alignment.

V	gegheue	te	bekīnene	hemelecheit		des	rike
B	gegeue	te	bekinnene	heimelijch ^t	.	des	rike

6. Analysis

6.1 Distinctive linguistic features

6.1.1 Random Forest Classifier.

Now that the transcriptions have been preprocessed and aligned, computational analyses can be performed on the dataset. A method used in previous research for identifying copying habits of the Speculum Scribe in VIENNA, ÖNB, SN 12.857, is to search for linguistic features that are distinctive of this manuscript or its two possible exemplars (Vandyck and Kestemont 2024, p. 886). Similarly to Haverals and Kestemont (2023a) and Vandyck and Kestemont (2024), a Random Forest Classifier will be trained. This is an algorithm that identifies important features for distinguishing between two classes (p. 12; p. 886). The classifier will be trained for both pairwise alignments, starting with the Viennese and Saint Petersburg alignment.

First, two bag-of-words models were created; one for each manuscript. These models form a numerical representation of the vocabulary of the texts. A bag-of-words model typically consists of a set of documents, a (limited) vocabulary of words or character n-grams from those documents and the frequency of each vocabulary entry (Haverals and Kestemont 2023a, p. 10). In this case, the documents are the sets of 85 slices that were created earlier. The vocabulary is comprised of the 1000 most frequent character trigrams (i.e. three consecutive characters) and four-grams (i.e. four consecutive characters) from the combined manuscript transcriptions. For example, the trigrams of the first sentence in Table 5 are "noc", "och", "ch_", "h_ē" and so on, while the four-grams are "noch", "och_", "ch_ē", "h_ē_" and so on.¹⁹ The table below shows a small segment of the bag-of-words model for the Viennese manuscript to illustrate how it is constructed.

¹⁹ ' _ ' represents a whitespace.

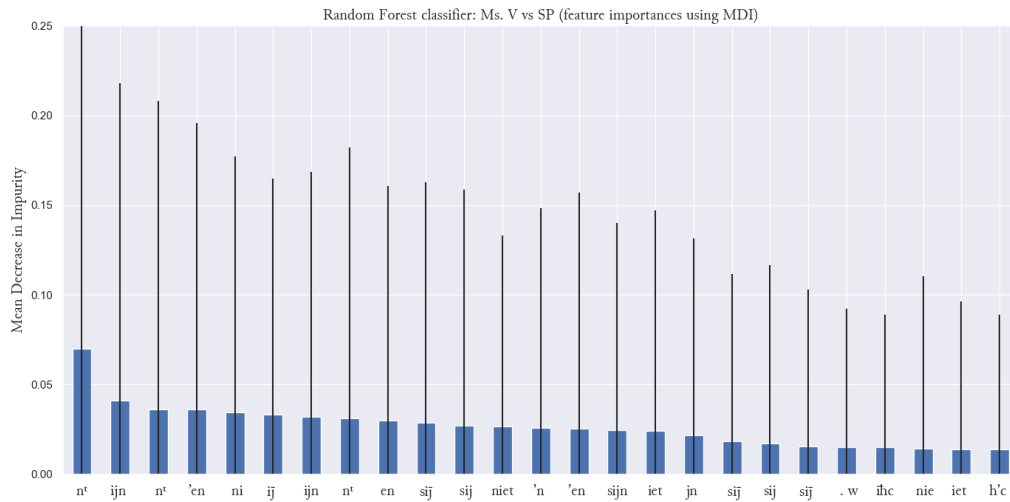
Table 7

The frequency of the four-grams " \bar{n}_{si} ", " \bar{n}_v " and " \bar{n}_w " for the first two Viennese slices from the Viennese and Saint Petersburg pairwise alignment.

	\bar{n}_{si}	\bar{n}_v	\bar{n}_w
0	0.040443	0.022060	0.007353
1	0.033160	0.007369	0.014738

The reason for creating a vocabulary of n-grams instead of words is because they are much more resistant against noisy data (Eder 2013, p. 608). The HTR models used for the diplomatic transcription had CER's of 2.7% and 4.58% respectively, meaning that a certain degree of noise in the dataset is present, especially in the damaged Viennese manuscript. However, the accuracy of authorship attribution in n-gram based stylometric research only starts to be affected once approximately 40% percent of a text consists of noise (Eder 2013, p. 609). Furthermore, n-grams are useful for revealing scribal behaviour on a smaller scale than word choices, namely the word-internal spelling decisions, such as abbreviations (Thaisen 2014 as cited in Haverals and Kestemont 2023a, p. 12). By limiting the n-gram vocabulary to 1000, a lot of low-frequency, possibly noisy data is also filtered out (Kestemont 2015, p. 168).

The bag-of-words models serve as training data for the Random Forest Classifier. The vectors of both bag-of-words models were stacked on top of each other to form one large matrix. Each vector then received the corresponding label 'V' (Vienna) or 'SP' (Saint Petersburg) so that the Random Forest Classifier can learn to differentiate between the two manuscripts. The algorithm calculates how important the trigrams and four-grams are for distinguishing between the two manuscripts after which it generates multiple decision trees with nodes based on this information. For example, one node could check if the frequency of 'ē' is higher or lower than a specific value. If a random text segment were to be entered into the tree, each node would lead it down one of two branching paths until it eventually reaches its most likely classification: VIENNA, ÖNB, SN 12.857 or SAINT PETERSBURG, BAN, O 256. This is done for every independent tree built by the Random Forest Classifier (Haverals and Kestemont 2023a, pp. 12-13; Vandyck, Haverals, and Kestemont 2024a, p. 22). The distinctiveness of a linguistic feature is measured by Mean Decrease Impurity (MDI), as shown in Figure 5. The higher the MDI of a linguistic feature, the more decisive it is for distinguishing between two classifications.

**Figure 5**

The 25 most distinctive tri- and four-grams when comparing VIENNA, ÖNB, SN 12.857 and SAINT PETERSBURG, BAN, O 256 ranked by Mean Decrease Impurity.

The plot above displays the 25 trigrams and four-grams with the highest MDI for VIENNA, ÖNB, SN 12.857 and SAINT PETERSBURG, BAN, O 256. "^tn" ranks the highest with a much higher MDI than the second most distinctive feature, making it especially decisive. It is followed by "ijn", "^tn", "'en" and "ni". Strikingly, the plot is for a large part filled with variations of "sijn" or "ijn" and their abbreviated counterparts "sij" and "ij". The distributions of these n-grams in the manuscripts reveal that "sijn" and "ijn" written in full are characteristic of the Saint Petersburg manuscript, while "sij" and "ij" are more typical for the Viennese manuscript (see Figure 6). Remarkably, "'en", "'en_" and "h'c_" are distinctive features in the Viennese manuscript and are largely absent in the Saint Petersburg manuscript, yet the opposite is true for "^tn". Thus, it cannot safely be concluded that the Speculum Scribe uses the modifier letter apostrophe more often in general. His use of the brevigraph likely differs based on the context. Additionally, "iħc", although it ranks fairly low, solely appears in the Saint Petersburg manuscript which means the Speculum Scribe prefers another abbreviation to refer to Jesus, which will be explored further in section 6.1.2.

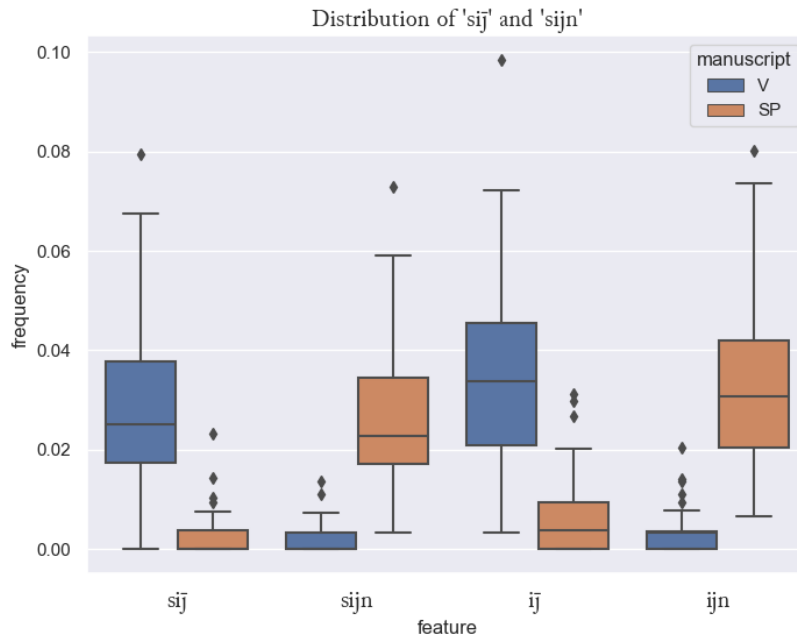
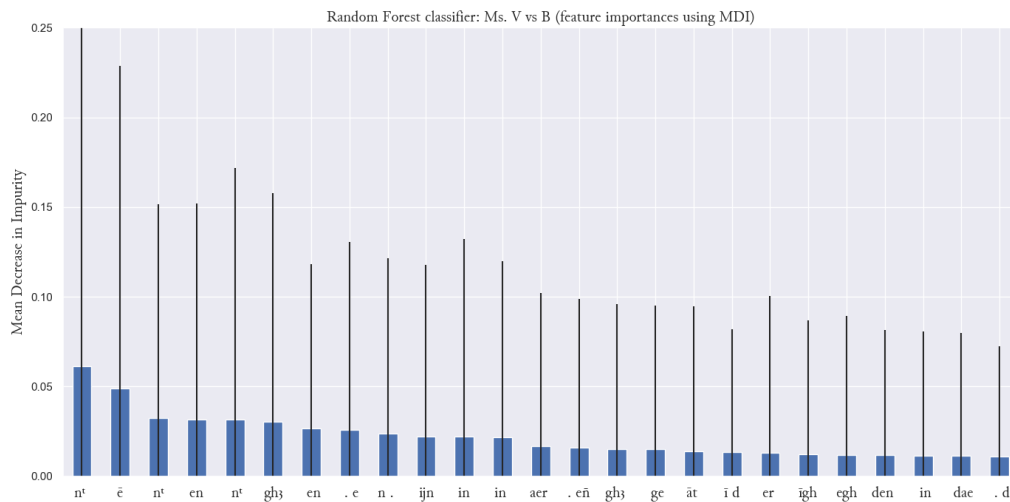


Figure 6

Distribution of "sij", "sijn", "ij̄" and "ijn" in VIENNA, ÖNB, SN 12.857 (V) and SAINT PETERSBURG, BAN, O 256 (SP).

The same method was used to compare the Viennese and Brussels manuscript. Two bag-of-words models were produced which contained the frequencies of the 1000 most frequent trigrams and four-grams in the combined manuscripts which were then stacked to use as training data for a Random Forest Classifier. The plot that compares the MDI of the 25 most distinctive trigrams and four-grams for this manuscript pair is shown in Figure 7. Once again, a variation of "n^t" is the most distinctive feature, specifically "n^t". The second most distinctive is "_ē _", which also has a noticeably higher MDI than all other features. It is followed by "_n^t _", "_en_" and "n^t". The second most distinctive feature, "_ē _", and the fourth most distinctive feature, "_en_", correlate to each other. The Speculum Scribe usually used the abbreviated form, while the scribe of Brussels, KBR, 2979 did not. The same applies to 'in', which he shortened more often than the Brussels scribe. In fact, every remaining n-gram that contains a brevigraph is distinctive of the Speculum Scribe.²⁰

²⁰ The only exception is "_eñ", but this is negligible since it is caused by the punctuation. "_eñ_" has a similar distribution across both manuscripts.

**Figure 7**

The 25 most distinctive tri- and four-grams when comparing VIENNA, ÖNB, SN 12.857 and BRUSSELS, KBR, 2979 ranked by Mean Decrease Impurity.

A comparison of both MDI plots leads to some interesting new conclusions. Seeing as "n'" and all of its possible combinations with whitespaces rank very high for both manuscript pairs, we can conclude that this is a scribal trait of the Speculum Scribe which he did not appropriate from either exemplar. This is further confirmed by the fact that "n'" does not appear a single time in the Saint Petersburg manuscript and only rarely in the main text of the Brussels manuscript (see Figure 8). In [Vandyck and Kestemont's \(2024\)](#) research, where they used a similar methodology to identify the most distinctive bigrams that include at least one brevisgraph for VIENNA, ÖNB, SN 12.857 compared to the rest of the Speculum Scribe's oeuvre, "n'" was *not* identified as a distinctive feature (p. 887). Therefore, it is likely that this unique scribal trait of the Speculum Scribe persisted throughout all of his works. The same reasoning can be applied to "sij" and "ij" to a lesser degree. As shown in Figure 6, the abbreviated forms are mostly used by the Speculum Scribe. While they do not appear as distinctive features in both of the MDI plots (only in Figure 5), the severe distribution contrasts and the fact that [Vandyck and Kestemont \(2024\)](#) did not identify them as a distinctive feature of VIENNA, ÖNB, SN 12.857 (p. 887) suggest that "sij" and "ij" are also characteristic elements of the Speculum Scribe's style that persist throughout his entire oeuvre.

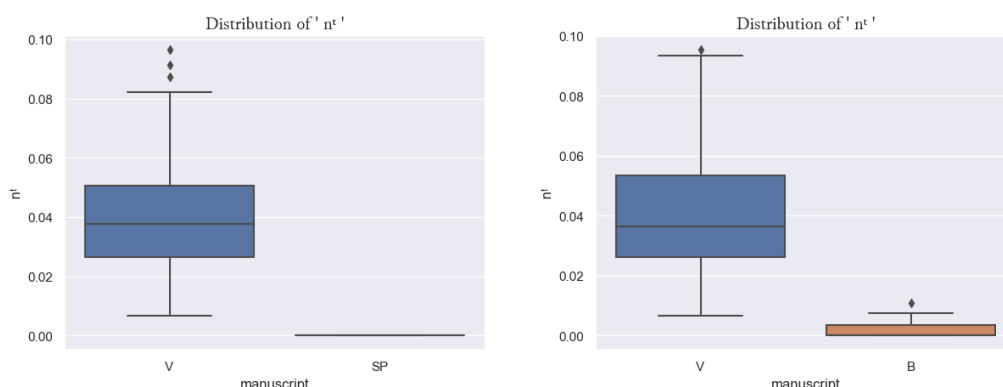


Figure 8

Distribution of "nt" for VIENNA, ÖNB, SN 12.857 compared to SAINT PETERSBURG, BAN, O 256 and VIENNA, ÖNB, SN 12.857 compared to BRUSSELS, KBR, 2979

The discussion of both MDI plots revealed a trend in the Speculum Scribe's abbreviation use. He seems to employ more brevigraphs compared to the scribes of the Brussels and Saint Petersburg manuscript. Yet, [Vandyck, Haverals, and Kestemont \(2024a\)](#) discovered that the Speculum Scribe uses fewer brevigraphs than usual in VIENNA, ÖNB, SN, 12.857, which they believe to be caused by him closely emulating BRUSSELS, KBR, 2979 and SAINT PETERSBURG, BAN, O 256 (pp. 12-13; 19). Nonetheless, these observations do not rule each other out. Even if he closely copied his exemplars, it is likely that his penchant for abbreviations remains detectable to a certain extent.

6.1.2 Burrows' Zeta.

Another computational method for exploring distinctive linguistic features is Burrows' Zeta. Although it has the tendency to favour infrequent words ([Schöch et al., 2018](#) as cited in [Haverals Kestemont, 2023a](#), p. 11), the results can still provide insights, especially in combination with our observations from the MDI plots. Burrows' Zeta requires a bag-of-words model for each manuscript per pairwise alignment. Instead of extracting a set of character n-grams from the manuscripts, this time the bag-of-words models will represent the frequency of the 150 most frequent word unigrams. Limiting the vocabulary, as is frequent in computational stylometric research ([Burrows 2006](#), p. 27), serves a number of advantages. Firstly, the most frequent words in a text tend to be shorter, which means that they are less likely to include noise ([Eder 2013](#), pp. 607-608). Additionally, more common words are likelier to appear in both of the manuscripts ([Binongo 2003](#), p. 11), ensuring a better analysis. Table 8 shows a segment of the bag-of-words model for the Viennese manuscript from the Vienna/Saint Petersburg alignment.

To clarify, Burrows' Zeta is a "keyness" measure, which entails that it can identify distinctive linguistic features by measuring their distinctiveness. Instead of focussing on feature frequency, Zeta takes feature dispersion into account. This prevents elements with a high frequency that only appear in a few of the slices from receiving a high Zeta score. For each of the 150 most frequent words, the "document proportion" (which ranges from 0 to 1) is calculated for both manuscripts. These scores are then subtracted

from each other, leading to values from -1 to 1 that will indicate distinctiveness (Du et al. 2021, pp. 181-184).²¹

Table 8

Segment of the bag-of-words model (150 most frequent words) for the Viennese manuscript from the Vienna/Saint Petersburg alignment.

	a	al	[...]	ōme	ōs
slice 1	0	1	[...]	0	1
slice 2	1	1	[...]	0	1
[...]	[...]	[...]	[...]	[...]	[...]
slice 84	0	1	[...]	1	0
slice 85	1	0	[...]	1	0

The output of Burrows' Zeta for the Viennese and Saint Petersburg manuscript is visualised in Figure 9. The words on the left are the 25 most distinctive words for the Saint Petersburg manuscript, which are in turn uncommon in VIENNA, ÖNB, SN 12.857. The lower the score on the x-axis, the less characteristic a word is for the Viennese manuscript. The right side of the plot contains the 25 most distinctive words for the Viennese manuscript. The higher the corresponding value, the more characteristic a word is for the Viennese manuscript and the less characteristic it is for the Saint Petersburg manuscript. Unsurprisingly "n^t" reaches a value of 1.0, which matches the observations from the MDI plot. As mentioned, this abbreviation does not appear at all in the Saint Petersburg manuscript. The Zeta scores also reveal how the Speculum Scribe preferably referred to Jesus. Instead of "ihc", he would often write "ih'c". The plot reconfirms another observation made in 6.1.1; it is uncharacteristic of the Speculum Scribe to write "sijn" in full.

Furthermore, "ē" achieves a high Zeta score while the unabbreviated form 'en' can be spotted on the left side of the plot. Combined with the observations from the MDI plot in Figure 7, this suggests that the Speculum Scribe's choice to use "ē" was not influenced by these exemplars. Cross-referencing the bag-of-words model in Table 7 reveals that the four-gram "_ē_" rarely appears in SAINT PETERSBURG, BAN, O 256, which is surprising considering the feature remained absent in Figure 5. Nonetheless, the low frequency of "_ē_" in the Saint Petersburg manuscript supports the conclusion that the Speculum Scribe's preference for "ē" was not appropriated from either manuscript.

Lastly, it is important to mention that a global analysis of the Zeta scores does not seem to indicate any general trends. Both manuscripts include specific distinct abbreviated words, but no disparity in abbreviation use or a contrasting use of specific brevigraphs can be clearly inferred.

²¹ For a thorough explanation on Burrows' Zeta, see: (Du et al. 2021)

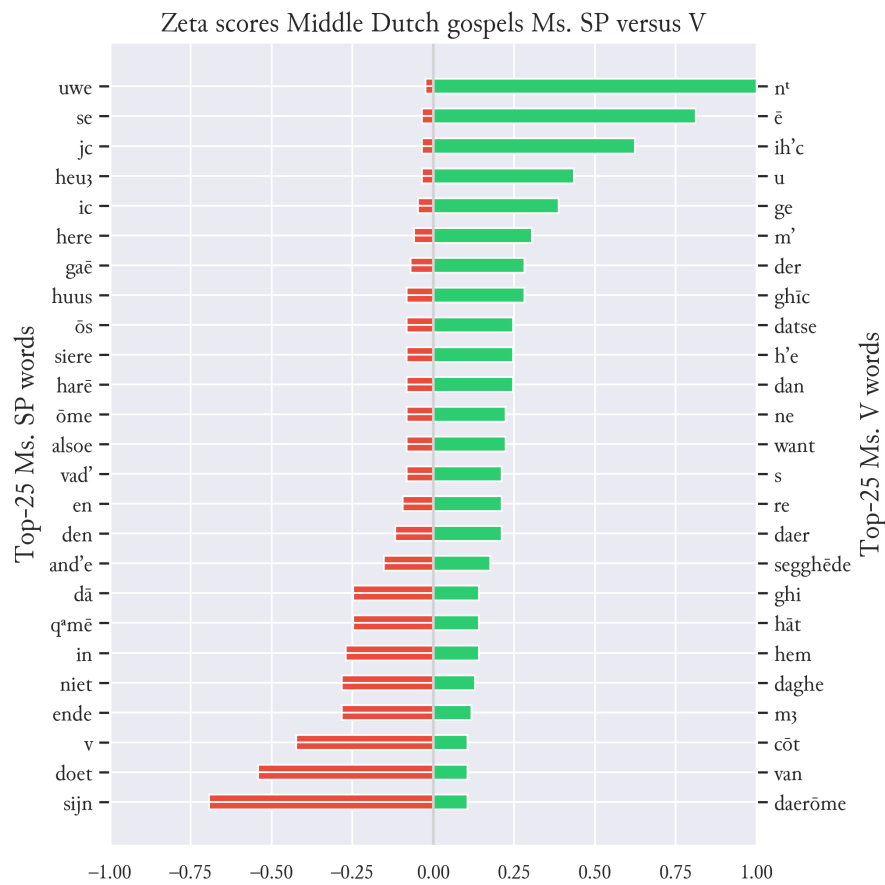


Figure 9
Zeta scores of the 25 most distinctive words for both manuscripts when comparing Vienna, ÖNB, SN 12.857 (V) and Saint Petersburg, BAN, O 256 (SP)

Zeta scores were also calculated to compare VIENNA, ÖNB, SN 12.857 and BRUSSELS, KBR, 2979; as shown in Figure 10 below. Most noticeably, the Speculum Scribe has a much higher tendency to abbreviate words than the scribe of the Brussels manuscript. Nearly the entire right hand side is filled with different abbreviated terms, while nearly every term associated with the Brussels scribe is written in full. While "ē" is commonly used by the Speculum Scribe, the scribe of the Brussels manuscript prefers to write "en", which also aligns with the other Burrows' Zeta plot and the MDI values. The same pattern is present once more for "n^t" and "niet".

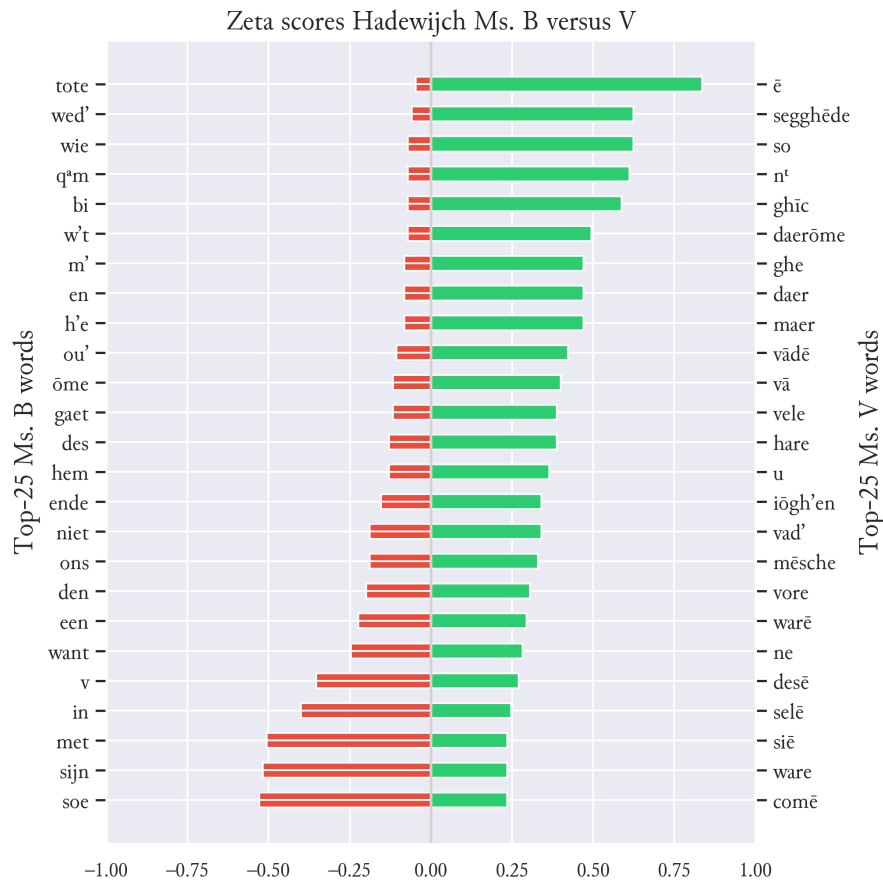


Figure 10
Zeta scores of the 25 most distinctive words for both manuscripts when comparing Vienna, ÖNB, SN 12.857 (V) and Brussels, KBR, 2979 (B)

When comparing both figures, a few unique traits of the Speculum Scribe's writing become noticeable. If a feature is distinctive of the Viennese manuscript in both plots, and thus indistinctive of both other manuscripts, it is most likely a characteristic of the Speculum Scribe's own copying style. It is clear that the Speculum Scribe prefers to use "u", while both possible exemplars use "v" instead. Once again, the same reasoning can be applied to the pairs "ē"/"en" and "n'"/"niet". He also distinctly uses "ghīc", "daer", "segghēde" and "daerōme"; terms which are not associated with either the Brussels or Saint Petersburg manuscript. The Speculum Scribe's disdain for 'sijn' is reconfirmed as well.

6.2 Diachronic (dis)similarities

Thus far, both the MDI plots and the Zeta score plots unearthed how VIENNA, ÖNB, SN 12.857 compares to BRUSSELS, KBR, 2979 and SAINT PETERSBURG, BAN, O 256 on a word-internal level and at the word-level. While many distinct differences have been identified, these observations only gain significant meaning if the latter two

manuscripts have truly been used as exemplars by the Speculum Scribe. A method for uncovering a connection between two manuscripts is to plot their diachronic (dis)similarities. The pairwise sequence alignments described in 5.2 play an important role in plotting an accurate diachronic trend as they ensure that the content of each manuscript pair still lines up after slicing the alignment table.

To plot the trends, the bag-of-words models created in 6.1.1 will be reused. As mentioned, their vocabulary consists of the 1000 most common tri- and four-grams from the combined texts of each manuscript pair. Each row represents one of the 85 slices in which a manuscript was divided and contains the frequencies for these character n-grams. However, instead of plotting a singular cosine distance value for each set of matching slices in a manuscript pair, bootstrapping was applied to calculate a distribution of cosine distances. Essentially, bootstrapping made it possible to calculate the cosine distance between two slices 500 times, where each time a random subset of 500 out of the 1000 character n-grams was selected. The median of these values will be represented by a dark line on the graph (q50), while the upper and lower bounds are plotted using dotted lines to visually display the distribution of the cosine distances.²²

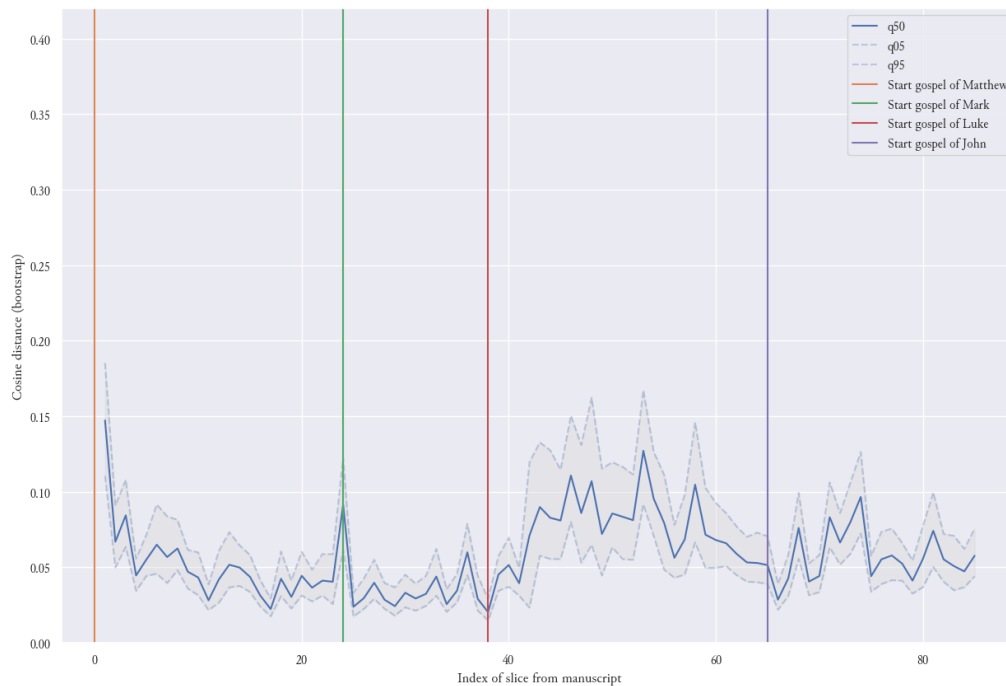


Figure 11

Diachronic trend for both manuscripts when comparing VIENNA, ÖNB, SN 12.857 (V) and SAINT PETERSBURG, BAN, O 256 (SP)

²² For an introduction to bootstrapping, see (Lasky 2023).

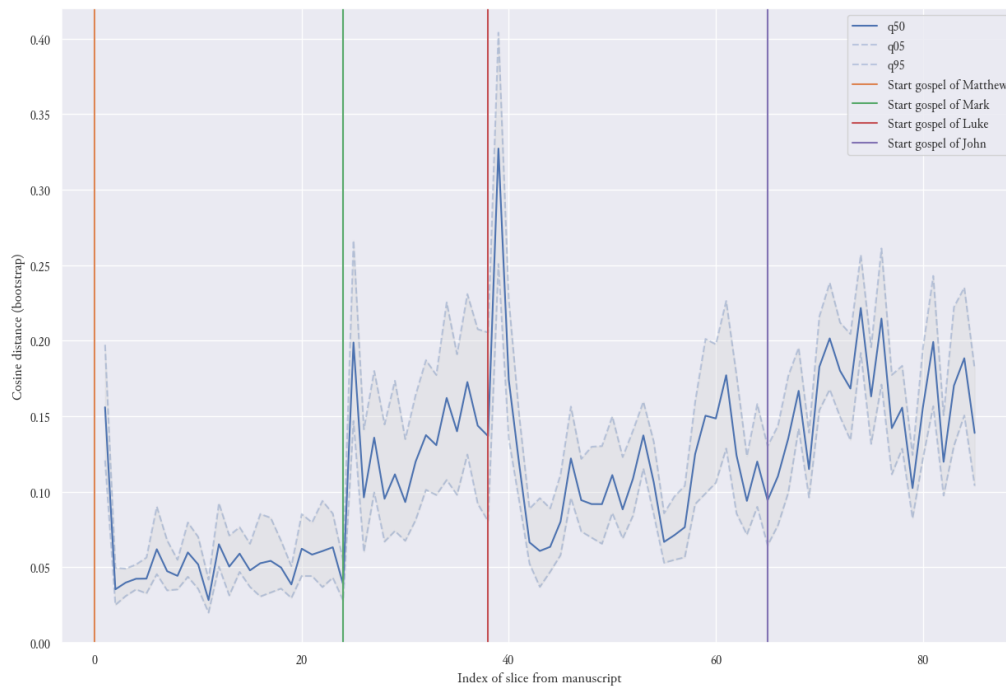


Figure 12

Diachronic trend for both manuscripts when comparing VIENNA, ÖNB, SN 12.857 (V) and BRUSSELS, KBR, 2979 (B).

Figure 11 and Figure 12 display the diachronic trend for the Viennese-Saint Petersburg alignment and Viennese-Brussels alignment respectively. The x-axis represents the slices of roughly 1000 tokens for the manuscripts, while the y-axis represents the cosine distance between the aligned slices which is on the same scale for both graphs. The lower the cosine distance is, the more similar the segments are. The vertical, coloured lines show where each gospel starts and ends.

What stands out in Figure 12 is the low, consistent cosine distance for the gospel of Matthew, which implies that the Speculum Scribe used BRUSSELS, KBR, 2979 as an exemplar. Aside from a deviating introduction — which can be observed in both graphs — the cosine distance is low for these segments and remains relatively stable at around 0.05 on the y-axis. Simultaneously, Figure 11 shows a converging trend for the gospel of Matthew that reaches a similar cosine distance of around 0.05 early on. It is possible that the Speculum Scribe started out by closely copying the Brussels manuscript and very quickly thereafter started closely referencing the Saint Petersburg manuscript as well. The most likely explanation is thus that this first gospel is heavily and almost equally based on both exemplars.

At the start of the gospel of Mark, Figure 12 suddenly displays a drastic rise and then remains relatively stable at a higher cosine distance value. While Figure 11 portrays a slight increase as the gospel of Mark starts, it remains stable at around 0.05 for the duration of the entire gospel. These patterns suggest that the Speculum Scribe distanced himself from the Brussels manuscript and instead started basing the second gospel closely on the Saint Petersburg manuscript.

When the gospel of Luke commences, another change takes place. The dissimilarities between VIENNA, ÖNB, SN, 12.857 and SAINT PETERSBURG, BAN, O 256

grow noticeably, which means the Speculum Scribe is no longer copying as faithfully as before. However, the plotted movement for this section is unusual. A diverging movement is shown that reaches its highest levels of dissimilarity around the middle of the gospel and then starts converging again. When the gospel of John starts, the cosine distances are lower once again, but not as low or as stable as they were during the gospel of Mark.

On the other hand, the cosine distances in Figure 12 seem to generally be slightly lower during the gospel of Luke compared to the previous gospel. However, there are also extreme spikes and drops present, which continue until the end of the manuscript in a diverging pattern. The orthographic variation also becomes more inconsistent in Figure 11 during the last two gospels, although the drops and rises are not as extreme. For the last two gospels, it seems unlikely that the Speculum closely referenced Brussels, KBR, 2979, while Saint Petersburg, BAN, O 256 was likely still referenced, only not as closely as before. Especially since, aside from the gospel of Matthew, the cosine distances for the entire plot are much lower for the VIENNA, ÖNB, SN, 12.857-SAINT PETERSBURG, BAN, O 256 comparison than the VIENNA, ÖNB, SN, 12.857-BRUSSELS, KBR, 2979 comparison.

Lastly, the sudden fluctuations in both plots should not be overlooked as they are likely not without cause. If a scribe's copying style coincidentally resembles the scribal profile of a hand in the exemplar, the diachronic trend would wildly differ once a different hand takes over. In Brussels, KBR, 2979 the first gospel was written mostly by one hand, the second by another, and the third and fourth by the same one (see Table 2). It is unlikely that this caused the fluctuating trend, otherwise a similar pattern would have likely occurred when the exemplar's hand switched for the second gospel. The gospel of Matthew, Mark and John were all written by the same hand in the Saint Petersburg manuscript (see Table 1). Once again, this does not explain the inconsistent patterns from the third gospel onward, however it could be correlated to the strange arch pattern for the gospel of Luke since only this gospel was written by a different hand in the exemplar. Perhaps the Speculum Scribe deliberately distanced himself more from this scribe's style, or specific traits of this hand's style simply did not match the Speculum Scribe's style. Although this would not explain why the manuscripts become more similar near the end of this gospel.

To conclude, while the orthographic trends showed promising patterns for the gospel of Matthew and Mark, they seem more unclear for the remainder of the gospels. This observation leads to three possible conclusions. Firstly, the Speculum Scribe commenced by faithfully copying his exemplars and became more liberal in his copying choices after finishing the gospel of Mark. This explanation seems the most unlikely. It would be more logically characterised by a gradual diverging variation trend, instead of sudden changes from the third gospel onward. Secondly, the Speculum Scribe faithfully copied the gospel of Matthew from BRUSSELS, KBR, 2979 and the gospel of Mark from SAINT PETERSBURG, BAN, O 256 after which he started alternating between closely referencing his exemplars or making stylistic choices by himself, resulting in irregular fluctuations on both plots. However, this also seems unlikely. Each slice on the x-axis represents roughly 1000 words. To cause these quick successions of peaks and drops, he would have to coincidentally alternate between strategies nearly every 1000 words. The third and likeliest possibility is that the Speculum Scribe made use of a third exemplar. This theory gains credibility from the fact that an unknown manuscript

containing the gospel translations is mentioned in a book list from Rooklooster.²³ This list is often referred to by its title "These are the Dutch books that belong to us"²⁴ and one of its entries is possibly BRUSSELS, KBR, 2979 (Kwakkel 2002, 24-27). Kwakkel (2002) showed in his Ph.D. thesis that many manuscripts made or owned by the monastery of Herne were later recovered from Rooklooster, which means this unknown manuscript could have also resided in Herne's library. Further research is necessary to confirm this hypothesis. Nonetheless, it can be concluded from these graphs that, at the very least, the gospel of Matthew was closely copied from BRUSSELS, KBR, 2979 and SAINT PETERSBURG, BAN, O 256, while the gospel of Mark was faithfully copied from SAINT PETERSBURG, BAN, O 256.

7. Conclusion

This master's thesis employed computational methods connected to the field of scribal profiling to establish if SAINT PETERSBURG, BAN, O 256 and BRUSSELS, KBR, 2979 truly served as exemplars for VIENNA, ÖNB, SN 12.857 and to what extent the Speculum Scribe appropriated from these exemplars. This research builds further on the hypotheses and findings of Kwakkel, who first made a connection between VIENNA, ÖNB, SN 12.857 and SAINT PETERSBURG, BAN, O 256 (Kwakkel 1999; Kwakkel 2002), as well as the discoveries by Vandyck, Haverals, and Kestemont (2024a), who have recently established an additional, possible connection to BRUSSELS, KBR, 2979.

The performed analyses depend on automatic transcriptions by trained HTR-models. The transcriptions from the *Silent Voices* project have proven fruitful in past research (Vandyck, Haverals, and Kestemont 2024a; Vandyck and Kestemont 2024). The HTR model trained specifically for this study aligned with the quality and guidelines for the *Silent Voices* project and succeeded in producing transcriptions of similar quality despite the damage to the Saint Petersburg manuscript. Thus, the transcriptions of the three manuscripts form a satisfactory corpus that should provide accurate results during the performed analyses.

The notion that the Speculum Scribe used SAINT PETERSBURG, BAN, O 256 as an exemplar seems extremely likely. The diachronic trend for the Viennese-Saint Petersburg comparison revealed that both manuscripts are orthographically very similar, especially for the gospels of Matthew and Mark. The Speculum Scribe probably made a (faithful) copy of these two gospels, although the same cannot be said with full certainty for the remaining two gospels. The findings of this thesis also indicate that the gospel of Matthew in the Viennese manuscript was closely based on the Brussels manuscript. Yet, it seems unlikely that the remainder of the Brussels manuscript was (closely) referenced.

The conclusion that both manuscripts served as, at least, partial exemplars for VIENNA, ÖNB, SN 12.857 also lends credibility to the identified linguistic traits of the Speculum Scribe. Combined with the findings of Vandyck and Kestemont (2024), it becomes highly probable that "n^t", "sij" and "ij" are characteristic of the Speculum Scribe's entire oeuvre. Additionally, the abbreviated words "ē", "ghīc", "daer", "segghēde" and "daerōme", as well as his preference for "u" instead of "v", were not appropriated from either exemplar. Lastly, the Speculum Scribe uses notably more brevigraphs than the scribe of the Brussels manuscripts. This also possibly applies to the Viennese-Saint Pe-

²³ According to Kwakkel (2002) this cannot refer to VIENNA, ÖNB, SN 12.857 or SAINT PETERSBURG, BAN, O 256 as these manuscripts most likely only arrived in Rooklooster after the entry was made (p. 27).

²⁴ Own translation.

tersburg comparison, although it was only indicated by the MDI plots and not the Zeta scores. Further research into the abbreviation patterns and density for these manuscripts is necessary to confirm this.

To conclude, because of the strange orthographic variation patterns that were identified when analysing diachronic trends, specifically the sudden fluctuations after the second gospel and the arch for the Viennese-Saint Petersburg gospel of Luke comparison, this thesis proposes the idea that the Speculum Scribe used a third exemplar as reference. While a possible candidate for this exemplar did exist, it currently remains undiscovered. Nonetheless, further research into the Speculum Scribe's copying practices in VIENNA, ÖNB, SN 12.857 and his general scribal profile could contribute to this hypothesis.

References

- Binongo, José Nilo G. 2003. Who wrote the 15th book of oz? an application of multivariate analysis to authorship attribution. *CHANCE*, 16(2):9–17.
- Burrows, John. 2006. All the way through: Testing for authorship in different frequency strata. *Literary and Linguistic Computing*, 22(1):27–47.
- Coun, Theo. 2015. De zuid-nederlandse vertaling van de vier evangeliën (ca. 1200). In Y. Desplenter W. François A. den Hollander P. Gillaerts, H. Bloemen, editor, *De Bijbel in de Lage Landen : Elf eeuwen van vertalen*. Royal Jongbloed, Heerenveen, pages 58–67.
- Du, Keli, Julia Dudar, Cora Rok, and Christof Schöch. 2021. Zeta eta: An exploration and evaluation of two dispersion-based measures of distinctiveness. *Proceedings of the Computational Humanities Research Conference 2021*, 2989:181–194.
- Eder, Maciej. 2013. Mind your corpus: systematic errors in authorship attribution. *Literary and Linguistic Computing*, 28(4):603–614.
- Haverals, Wouter and Mike Kestemont. 2023a. From exemplar to copy: the scribal appropriation of a hadewijch manuscript computationally explored. *Journal of Data Mining & Digital Humanities*, 23, On the Way to the Future of Digital Manuscript Studies.
- Haverals, Wouters and Mike Kestemont. 2023b. The middle dutch manuscripts surviving from the carthusian monastery of herne (14th century): Constructing an open dataset of digital transcriptions. *Proceedings of the Computational Humanities Research Conference 2023*, 3558:135–152.
- Honkapohja, Alpo and Imogen Marcus. 2024. The long history of shortening: a diachronic analysis of abbreviation practices from the fifteenth to the twenty-first century. *English Language and Linguistics*, 28(1):43–71.
- Kestemont, Mike. 2015. A computational analysis of the scribal profiles in two of the oldest manuscripts of hadewijch's "letters". *Scriptorium*, 69(2):159–177.
- Kwakkel, Erik. 1999. Nieuwe fragmenten en een oude traditie. utrecht catharijneconvent bnh sj fragm h 70 en de overlevering van de middelnederlandse evangeliën(harmonie). *Queeste. Tijdschrift over middeleeuwse letterkunde in de Nederlanden.*, 6:166–191.
- Kwakkel, Erik. 2002. *Die dietsche boeke die ons toebehoeren: de kartuizers van Herne en de productie van Middelnederlandse handschriften in de regio Brussel (1350-1400)*, volume 27. Peeters Publishers.
- Kwakkel, F. 2003. A meadow without flowers. what happened to the middle dutch manuscripts from the charterhouse herne? *Quaerendo*, 33:191–211.
- Lasky, Jack. 2023. Bootstrapping (statistics) | EBSCO. <https://www.ebsco.com/research-starters/science/bootstrapping-statistics>.
- McIntosh, Angus. 1973. Word geography in the lexicography of medieval english. *Annals of the New York Academy of Sciences*, 211(1):55–66.
- McIntosh, Angus. 1975. Scribal profiles from middle english texts. *Neuphilologische Mitteilungen*, 76(2):218–235.
- Needleman, Saul B. and Christian D. Wunsch. 1970. A general method applicable to the search for similarities in the amino acid sequence of two proteins. *Journal of Molecular Biology*, 48(3):443–453.
- Nevens, Frank. 2014. ... het gefluister van een zachte bries. over de essentie van kartuizers en hun orde. In *Het zwijgzame verleden: 700 jaar kartuizerkroniek: klooster van Onze-Lieve-Vrouwe-Kapelle te Herne*. Gemeentelijk Studiegenootschap Hernse Kartuis, pages 21–35.

- van Oostrom, F. P. 2013. *Wereld in woorden : geschiedenis van de Nederlandse literatuur 1300-1400*. Amsterdam : Prometheus.
- READ-COOP SCE. n.d.a. Features. <https://www.transkribus.org/features>.
- READ-COOP SCE. n.d.b. Model setup and training. <https://help.transkribus.org/model-setup-and-training>.
- Vandyck, Caroline, Wouter Haverals, and Mike Kestemont. 2024a. Making characters count. a computational approach to scribal profiling in 14th-century middle dutch manuscripts from the carthusian monastery of herne monastery. In *Approaches to Digital Codicology: Interdisciplinarity and intersections*. Brepols Publishers.
- Vandyck, Caroline, Wouter Haverals, and Mike Kestemont. 2024b. Silent voices: The incredible story of a dozen solitary men in the calamitous 14th century. <https://hosting.uantwerpen.be/silent-voices/>.
- Vandyck, Caroline and Mike Kestemont. 2024. Abbreviation application: A stylochronometric study of abbreviations in the oeuvre of herne's speculum scribe. *Proceedings of the Computational Humanities Research Conference 2024*, 3834:881–891.
- Vis, G.J., P.J. Verkruijsse, H. Van Gorp, D. Delabastita, G.J. van Bork, Lars Bernaerts, Frank Willaert, Esther Op de Beek, Nina Geerdink, Sara Van den Bossche, and Orsolya Réthelyi. n.d.a. evangeliënharmonie. https://www.dbnl.org/tekst/dela012alge01_01/dela012alge01_01_00524.php.
- Vis, G.J., P.J. Verkruijsse, H. Van Gorp, D. Delabastita, G.J. van Bork, Lars Bernaerts, Frank Willaert, Esther Op de Beek, Nina Geerdink, Sara Van den Bossche, and Orsolya Réthelyi. n.d.b. legger. https://www.dbnl.org/tekst/dela012alge01_01/dela012alge01_01_01276.php.
- Vis, G.J., P.J. Verkruijsse, H. Van Gorp, D. Delabastita, G.J. van Bork, Lars Bernaerts, Frank Willaert, Esther Op de Beek, Nina Geerdink, Sara Van den Bossche, and Orsolya Réthelyi. n.d.c. perikoop-1. https://www.dbnl.org/tekst/dela012alge01_01/dela012alge01_01_04018.php.
- Vis, G.J., P.J. Verkruijsse, H. Van Gorp, D. Delabastita, G.J. van Bork, Lars Bernaerts, Frank Willaert, Esther Op de Beek, Nina Geerdink, Sara Van den Bossche, and Orsolya Réthelyi. n.d.d. rasuur. https://www.dbnl.org/tekst/dela012alge01_01/dela012alge01_01_01651.php.

