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Language contact in historical documents: the identification and co-occurrence of Egyptian transfer features in Greek documentary papyri

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Abstract: The Egyptian-Greek contact situation has lasted almost a thousand years and many documents have been preserved to us from this period. In this paper, we apply a new quantitative approach to this rich corpus of documentary papyri to map the relationships between the linguistic variables (the variant spellings) and several non-linguistic variables. A multidimensional scaling of the co-occurrences of the linguistic variables shows that there is a strong association between most of the Greek variant spellings that can be explained by Egyptian phonological transfer, while others do not typically co-occur with them. Several new linguistic variables not yet connected to Egyptian phonological transfer also show a strong relation with the first group of features, some of them representing the same phonological transfer processes. A comparison of the contexts in which these variables are used allows us to further substantiate this observation: several of the previously and newly Egyptian-associated variables turn out to have a strong correlation with bilingual Egyptian-Greek documents or occur in Egyptian dominated environments. The spelling variants are chronologically dependent and different features are typically associated with different historical periods illustrating changes taking place in the Egyptian Greek contact variety over time. A multiple correspondence analysis shows that the variables strongly interact, illustrating the importance of a multifactorial approach combining various linguistic and non-linguistic factors.

Keywords: ancient Greek linguistics; ancient Greek phonology; Coptic phonology; language contact; multilingualism

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1 Introduction and methodology

The Greek documentary papyri provide an interesting corpus for linguistic study, because of the large amount of spelling variation found in these texts. Many of these variants are traditionally used as evidence for phonological changes taking place in the postclassical Greek language, resulting in the current pronunciation of Modern Greek (Gignac 1976; Horrocks 2010: 111–113; Mayser and Schmoll 1970; Teodorsson 1977), while several other variants that have not led to any changes appearing in Modern Greek are suspected to have been caused by the influence of the native Egyptian¹ language on Greek documents written in Egypt (Dahlgren 2017; Gignac 1970, 1976: 46–48, 1991). Most of these phonological studies did not address the context in any detail and observations about the social context have only been made for smaller subcorpora or individual writers (e.g., Clarysse 1993; Dahlgren 2017; Leiwo 2020; Vierros 2012). It remains, therefore, difficult to guess to what extent these observations apply to the whole corpus, which contact-induced spelling variants co-occur and how they are distributed across social contexts.

A multi-causal approach to language change (cf. Chamoreau and Légèlise 2012) is adopted here, in which contact-induced change is defined as “any linguistic change that would have been less likely to occur outside a particular contact situation” (Thomason 2001: 61–62). Language-internal factors may have contributed to the fact that certain linguistic features or phenomena were possible in a contact situation in the first place, enhancing the development of the contact features and accelerating the developments (see e.g., Joseph 1982). Thus, the same changes may occur in various places due to the typological properties of the languages involved rather than as a consequence of geographical spread (see Dahlgren 2017: 29–30, 2020; Dahlgren and Leiwo 2020; Stolk forthcoming). For instance, the most frequent form of variation in Greek, *iotacism*, still present in Modern Greek, was produced in Egypt by both L1 and L2 speakers. The vowel raising associated with this change probably began in native Greek speakers (Gignac 1976: 189–191, 239–242, 242–246, 273–275; Horrocks 2010: 167–170), but the under-differentiation of Greek front vowel series in Egyptian Greek, due to Coptic only having three of the four phonemes Greek had, may have accelerated the rate of development locally (Clackson 2010: 79–80; Dahlgren 2017: 100–112, 159–161; Gignac 1976: 235, 1991: 187; Girgis 1966: 71–72).

Our hypothesis is that the type of spelling variants that have been influenced by phonological transfer from Egyptian occur together in the same texts and in

¹ We use the term *Egyptian* when we are discussing phonological features that could be seen to have existed in the language stages even prior to Coptic (cf. Peust 1999). We use the term *Coptic* when we discuss evidence that comes directly from Coptic sources, such as the vowel qualities.

similar social contexts. In this paper, we will map relationships between particular variant spellings and non-linguistic variables for the full corpus of Greek documentary papyri. Since the Egyptian-Greek contact situation in Egypt lasted almost a thousand years and many documents have been preserved to us from this period, we will use exploratory quantitative techniques that are commonly used in linguistics (multidimensional scaling, correspondence analysis) to be able to better understand the interaction between the various linguistic variables as well as between linguistic and non-linguistic variables in a large number of texts.

This article is organised as follows. We will first provide our theory and methodology regarding the sociolinguistic situation in Egypt (Section 1.1) and the selection of the corpus and variables used in this study (Section 1.2). Then, we will explain the phonological background of Egyptian transfer features with the help of examples of contact-induced spelling variation mentioned in previous literature (Section 2). After that, we will introduce our quantitative research and examine the co-occurrences of the linguistic variables (Section 3) and the co-occurrence of these linguistic variables with the non-linguistic variables (Section 4). Section 5 will provide a discussion of the results and suggestions for further research based on the outcomes of this study.

1.1 Sociolinguistic background

After the death of Alexander the Great (323 BCE), Koine Greek became the *lingua franca* of the Hellenistic kingdoms in the Eastern Mediterranean. From the start of the Ptolemaic period (323–30 BCE), Egyptian scribes learned how to interact with the Greek-speaking government and how to produce the required documents in Greek, often alongside writing in the Egyptian demotic script (Thompson 1994: 74–83; Vierros 2012: 29–53). During the Roman period (30 BCE – 284 CE), the use of Egyptian as a written language was in decline (Depauw 2012) and Greek became the primary written language in all domains. The use of Latin in Egypt was limited compared to Greek (Adams 2003: 527–641; Depauw 2012; Evans 2012b). Coptic, the Egyptian language written in the Greek alphabet, was introduced during the third century CE, but it took until the sixth century before it started to be used outside of private and monastic contexts (Clackson 2010; Fournet 2020). Intensive Egyptian-Greek language contact continued for almost 1,000 years until the Arab conquest in 641 CE. Bilingualism must have played an important role in everyday life in Egypt (Bagnall 1993: 240–251) and different levels of bilingualism seem to have co-existed at all times (Fewster 2002). Egyptian native speakers must have continued to learn to speak and write Greek as a second language throughout this

period, for example during scribal training at the lower level of the administration (see Bucking 2007).

Adult second language learning may lead to what Thomason and Kaufman (1988: 38; Thomason 2001: 74–75) call “shift-induced interference” (also occurring without actual shift) in the target language (TL). Shift-induced language transfer² typically leads to changes at the phonological level or the syntactic one, instead of the lexicon. The influence of native language phonology on the pronunciation of the target language may result in a group-particular accent and eventually emerge as a new variety of the target language (Matras 2009: 221–226; Thomason 2001: 74–75). Examples of phonological transfer can be seen worldwide in many similar contact varieties that have emerged through conquest, e.g., Indian English, Irish and (Highland) Scottish Englishes and Finland Swedish. Similarly, it is possible that Greek changed over time in such a way that the Egyptian-influenced features came to be L1 features, as part of a contact variety used in Egypt (Dahlgren 2022). If this were to be the case, this should reflect on the distribution of Egyptian features across social contexts (see Section 4). Generally, we expect the variables only present in Egypt to show a different social distribution than the variants due to phonological changes taking place throughout the Greek speaking area and still being present in Modern Greek. While some of these general changes in Greek may indeed be less associated with Egyptian contexts, others may turn out to co-occur more frequently than expected with the Egyptian transfer features. This would be in line with our multi-causal approach to language change. Contact with other languages, especially Latin, may have influenced the Greek language in Egypt as well, but the limited availability of metadata (see Section 1.2) do not allow us to address the impact of other languages quantitatively in this study.

1.2 Annotation of linguistic and non-linguistic variables

The starting point of our study is the 4.9-million-word corpus containing more than 50.000 published Greek documentary papyri available in digital format through the Papyrological Navigator (www.papyri.info).³ Standard orthography is

² Instead of using Thomason’s original terminology, we are using the term “transfer” to describe a situation that previously was described under the term “interference”.

³ The Papyrological Navigator is a portal for the study of papyrus documents integrating information from other website and databases, including an electronic corpus of all published Greek documents written on papyrus, ostraca, or wooden tablets (Duke Databank of Documentary Papyri). For this study, we also used the tools of the Trismegistos platform, an interdisciplinary portal for the study of ancient texts (www.trismegistos.org). The corpus for this study was based on a Trismegistos scrape from the Papyrological Navigator (state 2016) of the transcriptions of 52.761

understood here as “a more or less binding norm that can lead to criticism in case of non-compliance” which is developed by “the practices of a community of writers within a certain period” (Rutkowska and Rössler 2012: 214). Spelling variants that deviate from what is understood as the standard spelling of (Koine) Greek have been marked by the first editor or during digitalisation of the text (Stolk 2018). These original and regularized forms have been annotated describing the interchange of graphemes (Depauw and Stolk 2015). These interchanges serve as the linguistic variables in our analysis.⁴

The papyrus corpus confronts us with many of the challenges of linguistic research in historical corpora, concerning (i) the representativeness due to the non-random preservation of historical documents, (ii) restricted knowledge about the social and cultural context, and (iii) potential differences between written and spoken varieties (Hernández-Campoy and Schilling 2012). As we are dealing with historical documents, we have to focus on the written data for the linguistic variables, while the number of non-linguistic variables that we can test is limited to the (quantitative) information that we have available at the moment for the whole corpus. The results of this large-scale quantitative study could, of course, be compared later to smaller subcorpora for which more detailed information is available about the social context.

Contextual information that is generally available for all texts in the papyrus corpus includes the date, provenance, genre, language(s) and material of the text. The date was categorized into the three main periods generally distinguished for Greek papyri in Egypt (Pestman 1994: 6–12): Ptolemaic period (third to first century BCE), Roman period (first to third century CE) and Byzantine period (fourth to seventh century CE). The information about the provenance also needed to be summarized into more general categories. Therefore, two geographical variables were introduced: region and place. For most texts a general region in Egypt (e.g., Lower Egypt, Upper Egypt, Fayum, Eastern Desert, Non-Egypt) can be reconstructed as a provenance. For many texts, also the specific place of writing or the village or city where the text was found could be identified.

The identification of the genre was based on a division into the following prototype genres: letter (including private, business and official letters), contract, receipt, list, report (including administrative reports, pronouncements from the

digitalized Greek texts. A collection of the editorial regularizations of spelling and morphology in those texts is available in Text Irregularities (www.trismegistos.org/textirregularities) and lexicographical and morphological analysis of all words in these texts is available in Trismegistos Words (www.trismegistos.org/words).

⁴ The Greek alphabet is transcribed in this article following the EAGLL transcription guidelines, see Giannakis (2013).

government and certificates) and petitions (for the categorization see Stolk 2021: 306–310). Apart from the genre, information about the number and type of languages used in the document was also taken into account, summarized as monolingual Greek versus bilingual Greek-Egyptian documents. The two most commonly used writing materials in our corpus are papyrus (a material similar to thick paper, made from the papyrus plant) and *ostrakon* ‘potsherd’ (Latin spelling of the Greek *óstrakon*; plural *ostraca*).

2 Identification of Egyptian transfer features

Although Egyptian phonological transfer may be expected in the Greek spoken in Egypt based on the typology of the situation as described above in Section 1.1, it is not self-evident to observe these features in written texts. The first limitation is our lack of knowledge of the pronunciation of Egyptian during earlier periods of Greek in Egypt. From the third century BCE until the end of the second century CE, the Egyptian documents were commonly written in the demotic script, a cursive form of the Egyptian hieroglyphs. Demotic does have some alphabetic signs, but not for vowels (Allan 2013: 4–5). The full state of the Egyptian phonological system becomes, therefore, only apparent when the Coptic script starts to be used to write Egyptian during the third and fourth centuries CE. Coptic uses the Greek alphabet, including the vowels, with several additional consonants, and this makes it possible to reconstruct the pronunciation of both consonants and vowels in Coptic and earlier Egyptian (Allan 2013; Peust 1999) and to compare the spelling of Greek words in Coptic and Greek (Clackson 2010; Girgis 1964, 1971).

In order to identify possible contact-induced features in Greek texts, one would ideally like to compare the characteristics of the Greek and Egyptian phoneme inventories with the spelling of phonemes in Greek written by Egyptian speakers (Dahlgren 2020: 211–216). Although it is not always possible to identify the native language of the writer, there are clear exceptions where we do have some more information, such as in bilingual texts or archives from Egyptian-speaking contexts. Among the latter, there are the ostraca found in the temple of Narmouthis, written in Greek, Demotic or a mixture of the two (Dahlgren 2017; Rutherford 2010), or, for example, Egyptian monks noting down Greek hymns in Western Thebes (Stolk et al. forthcoming). Another example is provided by the few Greek papyri written with a brush, the usual tool to write demotic, instead of a reed pen, commonly used for Greek (Clarysse 1993). While L1 Greek bilingual writers are rare in Egypt, L1 Egyptian bilingual writers are very common, especially at the beginning of the Ptolemaic period. The ability to write with a brush – or rather

‘paint’ – demotic as well as Greek is, therefore, a strong indication for a L1 Egyptian.

However, even when we can argue that a certain scribe could also write Egyptian or had Egyptian as a native language, this does not automatically mean that we may be able to identify any Egyptian influences in these texts (Evans 2012a). Probably many of the Greek documentary papyri were written by bilingual scribes, but there were also many Egyptian scribes with a good Greek education that remembered and used conventional Greek orthography. Therefore, in order to find contact-induced spelling variation one does not only need to find people familiar with an Egyptian pronunciation of Greek, but also the contexts where scribes would allow this to affect the written language. Comparison of the Greek used in Egypt to Greek written in other areas may help to identify ‘typical’ Egyptian characteristics, but – taking a multi-causal approach to contact-induced change – even the changes also occurring elsewhere, due to contact with other languages or as a result of the typological properties of the language, could potentially be enforced in a Greek-Egyptian bilingual context. This illustrates the potential for a quantitative study combining all available evidence. In the following sections, we will discuss the contact-induced linguistic variables as identified in previous literature and explain why they were identified as potential Egyptian transfer features based on comparison of the phonemic systems and/or the spelling of loan words. All of them frequently occur in Greek papyri from Egypt and none of these sounds merged completely in Modern Greek.

2.1 Consonants

Underdifferentiation of Greek voiced stops is relatively frequent in Greek in Egypt and can be regarded as one of the least controversial examples of Egyptian influence. Underdifferentiation means that a (minimal) phoneme pair which has phonetic similarities in a language merges in the use of an L2 speaker, because the distinction does not exist in the native language of the said L2 language user (e.g., Weinreich 1968 [1953]: 18). Coptic no longer had the previous Egyptian opposition of voiced and voiceless stops (Gignac 1976: 64, 77; Peust 1999: 79–89) as can be observed from the nonstandard renderings of foreign names that carried this phonemic distinction, e.g., transcriptions of Semitic /d/, as well as from cuneiform transcriptions of Egyptian occasionally merging <t> and <d> as /d/, Aramaic transcriptions of Egyptian <t> and <d> varying them freely with one another, and the variation evident in Greek loanwords in Coptic (Clackson 2010: 80–81; Girgis 1970: 57–67; Peust 1999: 88–89). While merger of the voiceless and voiced consonants is present in Greek more generally before nasals, the voiceless dental /t/

and velar /k/ stops interchange with their voiced equivalents /d/ and /g/ almost unconditionally in Greek texts written in Egypt and can therefore be regarded as a contact-induced feature (Gignac 1970, 1976: 76–77; Horrocks 2010: 112).⁵

Egyptian contact has been suggested with less certainty for the variation between the consonants /p/ and /b/, /s/ and /z/ and /r/ and /l/. There is less variation within the labial stops <p> and , because Greek /b/ shifted to the fricative /β/, also present in Coptic at the same time (Gignac 1970, 1976: 64; Peust 1999: 135–136). Therefore, this phoneme pair was more easily identifiable to the L1 Egyptian writers and misspellings did not occur as often as with the two other stop pairs (Horrocks 2010: 112). There also seems to be some evidence for the variation between the voiced and voiceless sibilants /s, z/ (Gignac 1976: 120–132; Horrocks 2010: 112), and the liquids /r, l/. Although the latter interchange can also be found in Modern Greek (cf. e.g., Modern Greek ήρθα *értha* to Ancient Greek ἦλθον *élthon*), it already appears in Egypt from the Roman period onwards, especially in the Fayum area. Therefore, it is often understood in relation with the same feature belonging to the later Fayumic Coptic dialect (Gignac 1976: 102–110; Horrocks 2010: 112) (see examples in Table 1).⁶

Table 1: Selected examples of underdifferentiation of consonants in Greek papyri.

Phonemes	Nonstandard realisation	Standard Greek
<k, g> /k, g/	κεωρκων <i>keōrkōn</i> (O.Narm. 5)	γεωργῶν <i>geōrgōn</i> 'of farmers (gen.)'
<t, d> /t, d/	ατελφω <i>atelfhō</i> (O.Narm. 103)	ἀδελφῷ <i>adelphō</i> 'to brother (dat.)'
<p, b> /p, b/	πλατύτερος <i>platúteros</i> (P.Dime 3. 27, 106; 54 BCE)	βραδύτερον <i>bradúteron</i> 'slower'
<s, z> /s, z/	ζοματίσομε <i>zomatísome</i> (P.Mich. 13. 662; 7th century CE)	σωματίζομαι <i>sōmatízomai</i> 'I execute (the contract)'
<r, l> /r, l/	πάριν <i>párin</i> (SB 12. 11017; 12 CE)	πάλιν <i>pálin</i> 'again'

⁵ The variation between <κ> /k/ and <γ> /g/ due to assimilation to a following voiceless or voiced consonant, e.g., ἐγ λόγου *eg lógou* instead of ἐκ λόγου *ek lógou* 'from account', is very common in Greek and is regarded here as a separate variable from the interchange of voiced and voiceless velar plosives in other contexts. The same applies to variation between aspirated and non-aspirated stops due to assimilation to a following aspirated sound, e.g., καθ' ἐκάστην ἡμέραν *kat^h hekástēn hēméran* and κατ' ἐκάστην ἡμέραν *kat' hekástēn hēméran* 'every day'.

⁶ It is also attested, however, elsewhere in Egypt in our corpus in smaller quantities, see, e.g., the Greek spelling of Egyptian names in Blasco Torres (2017: 675–683), or the provenance of the interchanges in TM Text Irregularities.

2.2 Vowels

Underdifferentiation could not only apply to consonants, but also to the pronunciation of the vowels. For instance, Coptic did not have the phoneme /y/ (Peust 1999: 201), which is written as <u> in Greek and distinguished from other front/close vowels until the (early) Byzantine era (Gignac 1976: 235, 262–273). Thus, the sound to mark the Greek close front rounded vowel /y/ could be replaced by the L1 Egyptian writers with the nearest equivalent available in Egyptian-Coptic, namely the close back rounded vowel /u/ written as <ou> (see also the example in Table 2 below). Apart from underdifferentiation of phonemes that are not present in the Egyptian language, there are two other important characteristics of the vowels in Egyptian that may have influenced the Greek language spoken in Egypt: stress and co-articulation.

First of all, from the evidence available, Coptic seems to have been a stress-timed language, often reducing the quality of vowels in unstressed syllables, whereas Greek was mora-timed or syllable-timed⁷ (Dahlgren 2017: 133–138, 2020; Kiparsky 1973: 796–805).⁸ The Greek vowels <ē>, <o> and <ō> only occur in stressed syllables in Coptic, while the vowels <(e)i>, <ou>, <e> and <a> are attested in stressed and unstressed syllables. The <(e)i> /i/ and <ou> /u/ seem to

Table 2: Selected examples of variant spellings of vowels in Greek papyri.

Phonemes	Nonstandard realisation	Standard Greek
<u, ou> /y, u/	πουρου <i>pourou</i> (O.Narm. 42, 47)	πυροῦ <i>pyrou</i> ‘of wheat (gen.)’
<e, o> /ε, ο/	Σεκναπαίου <i>Seknapaiou</i> (BGU 3. 805, 1; 138 CE)	Σοκνοπαίου <i>Soknopaiou</i> (name of an Egyptian god)
<a, o> /α, ο/	γέγρεφε <i>gégrephe</i> (P.Tebt. 3. 840, 7; 113 BCE)	γέγραφε <i>gégraphe</i> ‘he has written’
<e, a> /ε, α/	δοῦναι <i>dónai</i> (O.Did. 382, 13, 15 and 16; before ca. 110–115 CE)	δοῦναι <i>doúnai</i> ‘to give (inf.)’
<o, ou> /ο, u/	ἀποστηλῶ <i>apostēlō</i> (P.Mich.Zen. 29, 10; 256 BCE)	ἀποστελῶ <i>apostelō</i> ‘I will send’

⁷ Modern Greek is still between syllable-timed and stress-timed (Grabe and Low 2002: 515–546).

⁸ Accents are not generally written in Greek and Coptic documents from this period but have to be reconstructed based on later evidence and spelling variation, see e.g., Allan (2013: 23–24) and Gignac (1976: 325–327).

be most stable across dialects, while <e> and <a> often alternate (Allan 2013: 13–17; Peust 1999). Coptic had no unstressed [o] or [ɔ] (Dahlgren 2020: 214). Therefore, we encounter spellings like *Seknapaïou* for the Egyptian god Soknopaios, generally spelled as *Soknopaïou* in Greek. The value of /e/, /a/ and /o/ in stressed syllables differed across dialects, but no Coptic dialect had more than two phonemes in opposition for the corresponding three phonemes in Greek (Gignac 1976: 285–286). Interchanges between these three phonemes are rare in Greek outside of Egypt, but common in Greek loanwords in Coptic (Clackson 2010: 80; Girgis 1966), which is why this feature is often interpreted as a sign of Egyptian transfer (Gignac 1976: 285–292, 1991: 187).

There is also variation between the unstressed Greek <o> /o/ being replaced with <ou> /u/, and vice versa, the stressed Greek <ou> /u/ replaced with <o> /o/ (Gignac 1976: 211). Although the sounds may have been close together in pronunciation and variation between /u/ and /o/ is also common typologically (e.g., in Latin and the Italic languages), it is also in accordance with the (later) Coptic phono-orthographic rules replacing the Greek unstressed vowel /o/, being part of the stressed vowels' inventory in Coptic, with one of the unstressed rounded vowels /u/ (Clackson 2010: 80; Dahlgren 2017: 153; Peust 1999: 250–254). Apart from being stressed or unstressed, vowel quality in Egyptian is also influenced by the consonantal context. Coptic had /o, u/ allophony near nasal consonants /n, m/ and interchanges are also common in Greek loanwords in Coptic (Gignac 1976: 213–214; Horrocks 2010: 112; Layton 2000: 21; Peust 1999: 222–223, 238).

Consonant-to-vowel coarticulation is a feature of Egyptian, and more generally of other Afroasiatic languages, e.g., Arabic (see e.g., Bellem 2007: 174–175). It is caused by the stronger emphasis placed on consonant qualities due to word formational reasons. As a general principle, front consonants such as coronals can front the adjacent vowel quality, whereas back consonants, such as retroflex phonemes, velars, uvulars and pharyngeals, retract the adjacent vowel quality (Dahlgren 2020: 217; see also Flemming 2003: 335–336). Coarticulatory effects in Egyptian may have affected the front vowel series /i, e, a/ and have partially been treated within Coptology regarding the bivalent nature of Coptic <ē>, which is sometimes written for /i/, sometimes for /a/ (Allan 2013: 15–16; Lambdin 1958: 179; Peust 1999: 228–230). In Greek, the <ē>, originally /ε/, has shifted to /e/ and /i/ (Mayser and Schmoll 1970: 46; Teodorsson 1977: 219–220), but besides the frequent interchanges with <i, ei>, variation between <ē> and <e> is still attested in Egypt after the merger of the sounds, which could provide evidence for the Egyptian influence on the variation between <ē> and <e>.

3 Linguistic variables

While the previous section discussed the phonological evidence for individual spelling features in isolation, it is useful to take a broader view and look at the co-occurrence patterns of these features. When a particular spelling variant is related to language transfer, we would also expect it to co-occur more often with other spelling variants related to the same factor. In other words, we will adopt a ‘distributional’ approach to spelling variation. Distributional approaches to language (Lenci 2018; Turney and Pantel 2010), which have their origin in corpus linguistics, consider two linguistic objects (e.g., words, constructions, texts) similar if they have similar co-occurrence patterns. Although these methods are typically used in other areas of language, especially lexical semantics, applying this method to spelling variation is not fundamentally different: just like you can “know a word by the company it keeps” (Firth 1957), the co-occurrences of a particular spelling variant can be used to compare it to other spelling variants. Section 3.1 explains how to calculate the relatedness of individual spelling variants, relying on techniques described in Turney and Pantel (2010). Section 3.2 examines the resulting co-occurrence patterns in more detail for consonants (Section 3.2.1) and vowels (Section 3.2.2).

3.1 Co-occurrence of linguistic variables

First of all, we created a (square) matrix, which contains the co-occurrence frequencies of textual variants, i.e., the number of texts that contain both variants. To do so, we only used those spelling variants that occur at least 50 times in the corpus, to ensure that the statistical analysis is reliable. We reduced interchanges such as <e> instead of <ē> and <ē> instead of <e> to one variable – i.e., confusion between <e> and <ē> – after confirming that such interchanges generally show a similar distribution. An abridged version of this matrix is presented in Table 3.

Table 3 in itself does not reveal much: every single variant in the abridged version of this table has the highest amount of co-occurrences with the variable <i, ei>, but this is no surprise, since <i, ei> is the most frequent spelling variation in general (with 12,343 occurrences in total). Instead, the fact that the variation between <k> and <g> and between <t> and <d> co-occurs 171 times is more telling, since they only occur 1,172 and 602 times respectively. Therefore, we need to weigh this matrix by taking the differences in frequencies of the individual variants into account. We use the positive pointwise mutual information (PPMI) to do so, which compares the attested co-occurrence frequency to how high we would

Table 3: Abridged square matrix of the frequencies of co-occurrence of linguistic variables.

	<t, d>	<e, ai>	<k, g>	<ē, oi>	<i, ei>	...
<t, d>	1,172	359	171	17	745	...
<e, ai>	359	3,237	199	36	2,328	...
<k, g>	171	199	602	8	398	...
<ē, oi>	17	36	8	87	55	...
<i, ei>	745	2,328	398	55	12,343	...
...	...	...	...	...	...	...

expect it to be based on individual frequencies and returns a positive value when there is some association between the two variants (the higher, the stronger the association). Table 4 returns the following values for Table 3 above.

In Table 4, we see that <t, d> is much more strongly associated with <k, g> than <i, ei>, as we would expect. Each row in Table 4 above is a vector which represents the distributional profile of each variant, i.e., the variants it is most closely associated with. By calculating the distance between these vectors, we can calculate which variants tend to co-occur with the same variants. As is usual for distributional models for semantics (Turney and Pantel 2010: 160–161) we use the cosine measure to calculate this distance, i.e., by calculating the cosine of the angle between the two vectors. To give an example, for the variant <k, g> the lowest cosine distances (i.e., these variants share a similar profile) are found in Table 5.

While this already gives some information about Egyptian features – for instance, it is interesting to see that <k, g> co-occurs with very similar variants as <t, d>, and other variants related to Egyptian such as <e, ē> and <r, l> also show a low distance – it is difficult to compare all variants: to accurately plot the distance between each of them (in total 89), we would technically need a 88-dimensional plot. However, it is possible to use a dimension reduction technique to plot the distance between the individual variants as accurately as possible on a

Table 4: Weighed matrix of the frequencies of co-occurrence of several variables.

	<t, d>	<e, ai>	<k, g>	<ē, oi>	<i, ei>	...
<t, d>	4.52	1.34	2.70	2.16	0.47	...
<e, ai>	1.34	3.05	1.45	1.78	0.64	...
<k, g>	2.70	1.45	5.48	2.03	0.52	...
<ē, oi>	2.16	1.78	2.03	8.27	0.46	...
<i, ei>	0.47	0.64	0.52	0.46	1.12	...
...	...	...	...	...	...	...

Table 5: Distance between <k, g> and other variables.

Variants confounded	Distance
<t, d>	0.048
<o, ò>	0.086
<u, ē>	0.092
<i, ē>	0.102
<e, ē>	0.106
<e, ai>	0.108
<o, ou>	0.111
<u, oi>	0.131
<r, l>	0.131
<i, ei>	0.132

two-dimensional plot. We used non-metric multidimensional scaling (MDS), which takes a distance matrix as input (the cosine matrix) and returns the distances between the points in a lower (e.g., 2) dimensional space.⁹ This gives the following plot of all variants (Figure 1), with the variants described in Section 3 above marked in red.

This plot confirms that most of the spelling variants identified above as possibly caused by Egyptian phonological transfer, i.e., <t, d>, <k, g>, <z, s>, <r, l>, <e, ē>, <o, ou> and <a, e, o> are used in similar contexts (see Figure 2). Although there may have been multiple reasons for the interchange of these particular graphemes, there is reason to assume for all of them that they may have been influenced by Egyptian. The distributional profile of <u, ou> is a little different from the others and <p, b> is far removed from the other variants on the MDS plot (see Figure 1). This behaviour of <p, b> is consistent with the findings of Section 2.1, where we discussed that these particular phonemes might have been less problematic for native speakers of Egyptian. Thus, this plot suggests that the methodology used here can successfully identify co-occurrence patterns among the Egyptian-induced variants.

3.2 Linguistic variables co-occurring with the Egyptian transfer features

If the co-occurrence of the above-mentioned variant spellings <t, d>, <k, g>, <z, s>, <r, l>, <e, ē>, <o, ou> and <a, e, o> is indeed influenced by language contact,

⁹ We used the function *isoMDS* in R package *MASS* (Ripley et al. 2021). The stress is 25.3, meaning that the dimension reduction technique is able to capture 74.7% of the variation of the 89 dimensions into 2 dimensions.

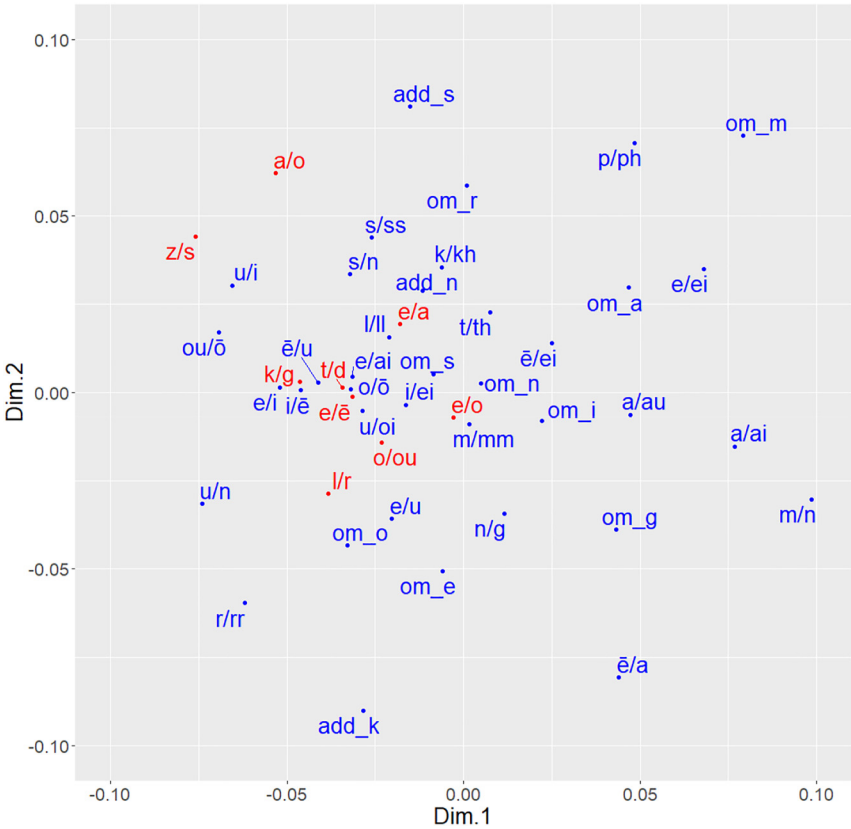


Figure 2: Close-up of the plot in Figure 1 with the potential Egyptian features (in red).

namely <k, kh>, <t, th> to a lesser extent <p, ph>, seem to have a similar distribution to some of the Egyptian transfer features. Table 6 shows some examples from the corpus.

Loss of aspiration seems most frequent in certain contexts, such as dissimilation before aspirates (see the second example in Table 6) and around nasals and liquids (see the first example in Table 6), as was also observed by Bubeník (1989: 225–227). The loss of aspiration, especially in the form of dissimilation before another aspirated stop, is also common in Greek generally. Although these aspirated stops have eventually changed into fricatives in Modern Greek, they do not seem to have been pronounced as fricatives in Egypt at this time (Gignac 1970: 197–201). Out of the Coptic dialects, Bohairic is the only one to have aspirated

Table 6: Examples of variation between voiceless and aspirated stops.

Phonemes	Nonstandard realisation	Standard Greek
<t, th> /t, th/	ἐρτῖν <i>ertein</i> (P.Mich. 8. 516, 10; late III CE)	ἐλθεῖν <i>elthein</i> ‘to go (inf.)’
<k, kh> /k, kh/	ἔκθρων <i>ékthrōn</i> (O.Narm. 1. 15, 1–2; II–III CE)	ἔχθρων <i>ékthrōn</i> ‘hated’
<p, ph> /p, ph/	Παμενώτ <i>Pamenōt</i> (O.Edfou 3. 395, 3; 3 CE)	Φαμενώθ <i>Phamenōth</i> (Egyptian month name)

consonants, so it is possible that the three-way Greek stop system <k, kh, g> and <t, th, d> might have caused confusion for Egyptian speakers and may have enhanced this general phenomenon locally.

Also, the interchange of single and double consonants <l, ll>, <m, mm> and <s, ss> and, to a lesser extent <r, rr>, show similar co-occurrences to the Egyptian transfer features, while <n, nn>, <p, pp>, <k, kk> and especially <t, tt> are further removed.¹⁰ Table 7 shows some examples of these types of simplification and gemination.

Egyptian had no geminate consonants, so it is not surprising that there is a lot of variation concerning them in Egyptian Greek, although it is interesting to see that this does not apply to stops, such as <t, tt>, <k, kk> and <p, pp>, to the same extent. Gignac (1976: 154–1162) already notes multiple examples, which seem indeed to be more numerous for liquids, nasals and sibilants than for the stops, but he does not mention that these interchanges may be influenced by Egyptian

Table 7: Examples of variation between single and double consonants.

Phoneme	Nonstandard realisation	Standard Greek
<l, ll> /l/	βουκολλο <i>boukóllo</i> (P.Michael. 69, 1; first half III CE)	βουκόλω <i>boukólōi</i> ‘cowherd (dat.)’
<m, mm> /m/	μάμης <i>māmēs</i> (SB 26. 16382, 16; II–III CE)	μάμμη <i>mámmēs</i> ‘grandmother’
<s, ss> /s/	ἀσπαζου <i>asspázou</i> (O.Did. 389, 11–12; ca. 115–120 CE)	ἀσπάζου <i>aspázou</i> ‘greet (imp.)’

¹⁰ As there does not seem to be a phonetic reason for the different position of <n, nn> and it has in fact a relatively high cosine similarity with several other Egyptian transfer features (e.g., <e, ē>, <o, ou>, <t, d> and <e, o>), the behavior of this feature might simply be less well represented through the dimension reduction.

language contact. Similar variants, however, are also attested in Greek loanwords in Coptic (Clackson 2010: 81). The frequency distinction between sonorants and stops could be connected to the more common appearance of sonorants as syllabic consonants in Coptic (Layton 2000: 29). Syllabic consonants are (mostly) written double when occurring before a vowel (Peust 1999: 263–268), possibly creating confusion about gemination in spelling. Dahlgren (2017: 135–138) also found that gemination in Egyptian Greek often appears before the syllable where Coptic allows word stress, such as in Greek *dokimázō* presented as *dokkimaze* in Coptic (P.Bod. 6 3, 17), and may have been a possible attempt to use geminate consonants to mark a stressed vowel in a word.

The omission and addition of word-final /n/ and /s/ are very frequent in Greek papyri and other post-Classical Greek sources and word-final /n/ can also be omitted in Modern Greek under certain conditions (Gignac 1976: 111–114, 124–126), but omissions and additions of /n/ and /s/ are also regularly attested in word-medial (syllable-final) position, see examples in Table 8 below.

The insertion of non-final <n> before a voiceless stop is used in Modern Greek to indicate a voiced stop after fricativization of the original voiced stops /b, g, d/. In Coptic, the insertion of a nasal before a voiceless stop also indicated a voiced allophone (Kahle 1954: 102–105; Peust 1999: 88–89), even though this voice distinction may not always have been perceived by the speakers (see also Section 3.1). Gignac (1976: 119, 1991: 187), therefore, argues that the omission and addition of nasals before stops in Greek in Egypt could be caused by transfer of this phenomenon from Egyptian. Indeed, more than half of the omissions of non-final /n/ in our corpus are in the position before a (mostly dental) stop (296 out of 524; of which 213 voiceless) and the same applies to the additions of /n/ (92 out of 182 before a stop; of which 64 voiceless). The effect of voicing of the (omitted) nasal on the voiceless plosive also shows in variant spellings of a voiced stop instead of a

Table 8: Examples of omission and addition of v <n> and σ <s>.

Phoneme	Nonstandard realisation	Example standard Greek
<n> /n/ (omission)	πέτε <i>péte</i> (BGU 4. 1195, 7; after 12–11 BCE)	πέντε <i>pénte</i> ‘five’
<n> /n/ (addition)	ἀνθρώνπους <i>ant^hrōnpous</i> (SB 26. 16386, 6; II–III CE)	ἀνθρώπους <i>anthrōpous</i> ‘men (acc.pl.)’
<s> /s/ (omission)	ἐκαστων <i>hékaton</i> (BGU I 86, 37; 155 CE)	ἐκαστον <i>hékaston</i> ‘each (acc.)’
<s> /s/ (addition)	ἀσπάσζω <i>aspászō</i> (P.Col. 7. 225, 24; end of II CE)	ἀσπάζου <i>aspázou</i> ‘greet (imp.)’

nasal and voiceless stop (Horrocks 2010: 113), see e.g., *dekapede* for *dekapénte* ‘fifteen’ in a receipt (P.Mich. XV 746; VI–VII CE). The nasal can also be fully assimilated to a following voiceless stop, such as in *prosénekken* for *prosénegken* ‘s/he brought’ (see Horrocks 2010: 113), or not assimilated to a following voiced stop, see e.g., *ángelos* instead of *ággelos* ‘angel’ (SB 10. 10269, 5; VI CE). The insertion of <n> before dental stops and sibilants (sometimes assimilated to the following stop) is also found in Greek loanwords in Coptic (Girgis 1970: 70–80). Even though the addition and omission of <n> is very frequent and also found in Modern Greek, these variants co-occur with other Egyptian transfer features more than other spelling variables and may, therefore, have been enhanced locally by the language contact with Egyptian.

Similarly, the majority of the non-final omissions of /s/ are attested in the position before a voiceless stop in our corpus (318 out of 547). Additions of non-final /s/, on the other hand, are less numerous (201 in total), less strongly connected to the other Egyptian features, and they are not only inserted before voiceless stops (26%), but also frequently before <z> (21%). This is remarkable, because clusters of <s> and <z> do not naturally occur in Greek. The occurrence of this spelling could be related to interchanges between <s, z> and the frequent interchange of a single and double spelling of /s/ (see Gignac 1976: 124). The simplification of a cluster with the retention of the voicing also shows by replacement with a voiced stop as in *apádomai* for *aspázomai* ‘I greet’ in a letter (P.Oxy. 31. 2599, 21; III–IV CE). Omissions and additions of /s/ are also attested outside of Egypt and, therefore, they are not generally regarded as an Egyptian transfer feature (Gignac 1976: 124, 131; Mayser and Schmoll 1970: 178–182). Even though we agree that the simplification of a consonant cluster or geminate consonant could also occur elsewhere without direct influence from Egyptian, they seem to be regularly found together with other Egyptian transfer features in the Greek documents in Egypt and may be (partly) Egyptian-influenced in those cases.

3.2.2 Vowels

The loss of vowel length distinction and monophthongization in postclassical Greek led to frequent spelling variation between the graphemes <i, ei, ē> for /i/, <e, ai> for /ε/, <u, oi> for /y/ and <o, ō> for /o/. As explained above (Section 3.1), Coptic did not have the phoneme /y/ and vowel quality was partly determined by the position of the stress in the word and consonant-to-vowel coarticulation. While the variation between <u, ou> did not seem to occur in similar distribution to many other Egyptian transfer features, <e, ē> and <o, ou> as well as several similar variables present themselves as being closely related. The most promising among the new variables would be <ē, u>, closely followed by other variant spellings of the

front vowels <i, u, ē, e>. Variant spellings of /y/ and the front vowels are also found in Coptic (Kahle 1954: 54–79), especially in Greek loan words in Coptic (Clackson 2010: 80; Girgis 1966), and for example in Greek hymns written by Coptic monks in Thebes (Stolk et al. forthcoming).

The rounded front vowel /y/ is expected to have merged with /i/ in the ninth century in Greek, but according to Gignac (1976: 266–267) this merger seems to have been completed significantly earlier in Egypt due to the absence of /y/ and unstressed <ē> in Coptic. The co-occurrence of the variants with consonantal underdifferentiation (see Sections 2.1 and 3.2.1) with the variation of the front vowel series <i, u, ē, e> gives additional credibility for Egyptian influence on this process. Similarly, the closely related distribution of the variation between the back vowels <ō, ou> and the other Egyptian features should not be surprising, considering the frequent variation between <o, ō> /o/ in Greek in Egypt and the Egyptian-influenced variation between <o, ou> /o, u/ (see Section 3.1) (see examples in Table 9).

The more common types of vowel variation in Greek, such as <i, ei, ē> for /i/, <e, ai> for /ε/, <u, oi> for /y/ and <o, ō> for /o/, also seem to show similar distributions to Egyptian transfer features according to the analysis in Section 3.1. These sound mergers have also taken place in Greek spoken in other areas and they are not assumed to be caused by Egyptian specifically, but the above-described Egyptian features may have accelerated the rate of merger of these Greek vowels in Egypt, especially in certain linguistic contexts (Gignac 1976: 235, 1991: 187; Horrocks 2010: 112; Leiwo 2020). The analysis of the social context should shed some light on whether or not these variants co-occur with other Egyptian features because they are indeed more commonly used by L2 speakers of Greek or perhaps due to other factors governing the distribution of these variables.

Omissions of vowels, such as /i/ and /o/, are very common also in Modern Greek, and have not been associated with Egyptian transfer before. Gignac (1976: 302–304)

Table 9: Examples of alternative variant spellings for vowels in Greek.

Phonemes	Nonstandard realisation	Standard Greek
<ē, u> /i/	κηνύ <i>kēnū</i> (P.Pintaudi 49, 4; late VII CE)	γυνή <i>gunē</i> 'woman'
<i, u> /i/	κλικιτάτῳ <i>klikitātō</i> (PSI 7. 836, 15; VI CE)	γλυκυτάτῳ <i>glukytātō</i> 'sweetest, dearest'
<e, u> /i/	προσβητέρῳ <i>prosbetērō</i> (P.Mich. 5. 308, 1; first half I CE)	πρεσβυτέρῳ <i>presbutērō</i> 'elder (dat.)'
<e, i> /i/	ἥμεσου <i>hēmesu</i> (SB 22. 15717, 12; 139 CE)	ἥμισυ <i>hēmisu</i> 'half'
<ou, ō> /u/	γνοῦναι <i>gnōúnai</i> (BGU 3. 846, 16; II CE)	γνῶναι <i>gnōnai</i> 'to know (inf.)'

Table 10: Examples of the omission of ι <i> and ο <o>.

Phonemes	Nonstandard realisation	Standard Greek
<i> /i/	ὕγένειν <i>hugénein</i> (P.Mich. 8. 464, 3; 99 CE)	ὕγιαίνειν <i>hugiaínein</i> ‘be healthy’
<i> /i/	εἰδύης <i>eidúēs</i> (P.Mich. 5. 250, 7; 18 CE)	εἰδυίης <i>eiduíēs</i> ‘knowing’
<o> /o/	σφυρίδιν <i>sphurídin</i> (SB 18. 13353, 4; I–II CE)	σφυρίδιον <i>sphurídion</i> ‘basket’
<o> /o/	ἀτουκράτρος <i>atoukrátros</i> (P.Michael 10, 4; 98 CE)	αὐτοκράτορος <i>autokrátoros</i> ‘emperor (gen.)’

gives examples of the omission of stressed and unstressed /i/ before back vowels and often after a liquid or nasal, e.g., *kuroú* for *kuríou* ‘lord (gen.)’ or *kurás* for *kurías* ‘lady (gen.)’, possibly pointing towards the change of /i/ to /j/ in this position. The loss of /i/ regularly occurs after a back vowel in our corpus, but attestations before a front vowel or between vowels are also frequent and may also be related to the loss of a glide, see examples in Table 10. The weak quality of unstressed vowels in Egyptian may have encouraged the addition and omission of vowels in writing, such as the omission of unstressed <o>, as commonly attested in Greek loanwords in Coptic (Girgis 1966: 81–85), although the frequency of this phenomenon and the occurrence of <o> especially in inflectional morphemes rather suggests that other factors may be involved here and Egyptian influence may only play a minor role in these cases.

4 Non-linguistic variables

While the previous sections looked at co-occurrence patterns in isolation, obviously these spelling variants cannot be divorced from the contexts in which they are found. Sections 4.1–4.3 give a broad overview of the social and textual environments in which the different spelling variants are found. Section 4.4 studies the interaction between these and other factors of the Egyptian transfer variants discussed in this paper.

4.1 Bilingual documents

The plots presented in Sections 4.1–4.3 show the relative distribution of all spelling variants with a frequency of at least 200 occurrences across different contexts. We manually divided the variants into the three groups we are interested in: the first 10 (in red) are variants with clear independent evidence of Egyptian transfer (the ones introduced in Section 2); the second 18 (in green) are variants for which there is

possible evidence as well based on the analysis in Section 3; and the final 24 (in blue) are variants for which we did not find clear evidence of Egyptian transfer. The height of the bars indicates relative frequency (for each context: see the Y axis) and the dotted line represents the median relative frequency for each context. The numbers in the bars indicate the absolute frequency.

Figure 3 shows which variants are relatively more frequent in bilingual Egyptian-Greek documents (as compared to monolingual Greek documents).

Several, but not all of the Egyptian features are relatively frequent in bilingual Greek-Egyptian texts (on average, 1.7% of all variants are in bilingual texts). This is particularly true for <k, g> (4.1%), <t, d> (4.3%), <e, o> (4.2%), <o, ou> (4.3%) and <e, u> (5.0%). On the other hand, variation between e.g., <a, o> (0.5%), <e, a> (0.6%) and <ou, u> (0.7%) occurs significantly less than average in bilingual texts. Also, generally frequent interchanges in the papyri, such as <i, ei> and <e, ai>, are not relatively more frequent in bilingual texts (both only 1.0% of all variants). Other variables which were not mentioned above but do have a high number of cases in bilingual texts – in particular <i, oi>, which has 4.2% of its attestations in a bilingual text – might also be interesting to study from an Egyptian transfer perspective.¹¹

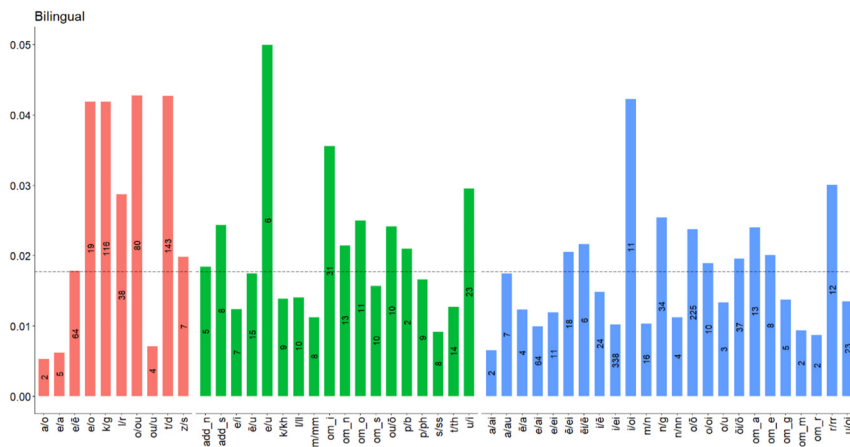


Figure 3: Plot of the relative frequency of variants in bilingual documents.

¹¹ The low number of cases of <a, o> and <ou, u> are not quite statistically significant, however, with $p = 0.1109$ and $p = 0.0900$ respectively with a 2×2 two-tailed χ^2 test. As for the other variables mentioned above, for <e, u>, $p = 0.0169$; for <e, a>, $p = 0.0231$; and for <i, oi>, $p = 0.0044$; while $p < 0.0001$ for the high numbers of <k, g>, <t, d>, <e, o>, and <o, ou>. Note though that in some cases the absolute frequencies are quite low: <e, u> has only 6 bilingual examples on 120 in total; <i, oi> has 11 on 260 in total and <e, o> has 19 cases on 453 in total. <o, ou>, on the other hand, has 80 cases in bilingual texts and <k, g> and <t, d> more than 100.

4.2 Chronological distribution

Figure 4 shows relative distribution of the spelling variants in the three different periods to which the documents can be dated: Ptolemaic (third to first century BCE), Roman (first to third century CE) and Byzantine (fourth to seventh century CE).¹²

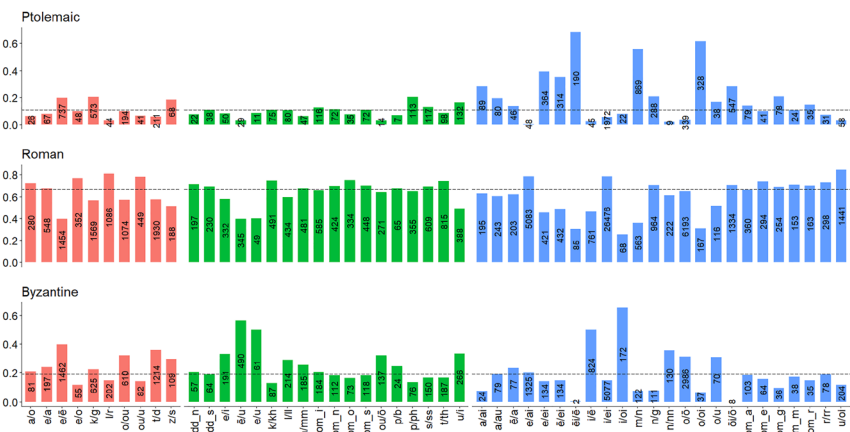


Figure 4: Plot of the relative distribution of variants across periods.

The features show a different chronological distribution. Several variants of the first group are relatively frequent in the Byzantine period and relatively infrequent in the Ptolemaic period, including <t, d>, <o, ou> and <e, a>. On the other hand, <k, g> is more strongly associated with the Ptolemaic period than the Byzantine period and <r, l>, <ou, u>, <e, o> and <a, o> correlate with the Roman period. The features <e, ē> and <z, s> are frequent both in the earliest (Ptolemaic) and latest (Byzantine) periods. The typical examples of Egyptian phonological transfer are thus not exactly the same for each period. This is probably due to the phonological changes taking place in the Greek language, which results in the higher number of features associated with the Roman and especially Byzantine period. If there was an Egyptian accent or Egyptian variety of Greek, it may have changed over time, just like any language.

Phonological transfer from Egyptian may also have had different or more pronounced results in different periods, possibly also related to the emergence of

¹² The height of the bar indicates how frequent the respective variant is in comparison to other variants in the same period and can therefore not be used to compare different periods to each other.

the Coptic writing system. For instance, <e> was commonly used for the word-final unstressed vowel (schwa) in many Coptic dialects, reflecting its place in the Coptic phonological system, and its variation especially in that position correlates with the unstressed <o> /o/ in many Greek verb forms. Furthermore, the unstressed /o/ and /ɔ/ had stress-related variation with /u/ in Coptic, which reflected on the orthographic level (Dahlgren 2016, 2017; Dahlgren and Leiwo 2020; Loprieno 1995: 48; Peust 1999: 211–213, 250–254, 270–273). This feature also seems to show up in Greek writing during the Byzantine period.

4.3 Geographical distribution

Figure 5 plots the relative distribution of the spelling variants in the different regions of Egypt.

Most Egyptian variables (i.e., the ones in the first and second group) are rather infrequent in Lower Egypt and frequent in Upper Egypt. Based on the geography of Egypt this is to be expected, as the location of Lower Egypt in the north would have been exposed to more non-Egyptian influences than the areas further south at a larger distance from the Mediterranean Sea, and had relatively fewer Hellenized cities. Some variants in the first two groups are also relatively frequent in the Fayum, such as <e, o>, <k, g>, <l, r> and <u, ou>.

Some specific villages show up as locations of documents with a more than average number of our selected variables. For example, several variables, in particular <k, g>, <r, l> and the omission of <o>, show a strong positive association with the village of Soknopaiou Nesos. Gignac (1970: 194) already argued that the

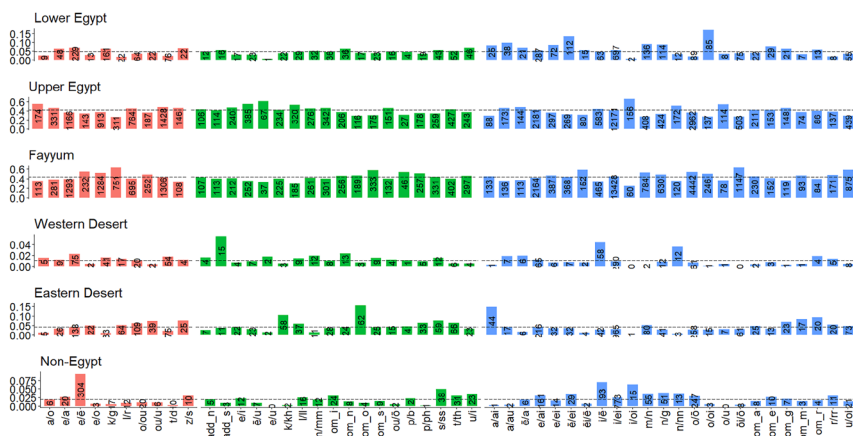


Figure 5: Plot of the relative distribution of variants across regions.

confusion of voiced and voiceless stops was especially common in bilingual Demotic-Greek contracts from Soknopaiou Nesos, a village in the northern Fayum mostly populated by Egyptian priests (Clarysse 2005: 22). Some other variables, such as <e, o>, <u, ou> and the omission of <n>, are also frequent in Tebtynis, another temple village at the southern end of the Fayum oasis. Many Greek and some bilingual contracts are preserved from the writing office of Tebtynis, run by Kronion son of Apion. These documents are known for the presence of nonstandard spellings (Bucking 2007: 236–238; Stolk 2021: 317–319), some of them perhaps influenced by the native language of (some of) the scribes.

Hitherto unmentioned is the fact that papyrus documents have also been found in a few places outside Egypt, most noticeably in Israel, Jordan and Syria. Some of the Egyptian features are relatively frequent in texts written outside of Egypt. For example, the variant spellings <z> /z/ written instead of <s> /s/ and <a> for <o> are also found in documents from Jordan. The variation between <e, ē>, which is especially frequent in texts outside Egypt, is regularly attested in documents from Nessana (Israel) and Petra (Jordan). While the Greek front vowels /i, e, ε/ have multiple interchanges in Byzantine Egypt, possibly under the influence of Egyptian, also the interchange of <e, ē> in Petra could perhaps be explained by the lower realization of the short high vowels, especially in the vicinity of emphatic consonants (consonant-to-vowel coarticulation, as in Egyptian), in the Arabic dialect spoken in Petra (Vierros 2018: 10–11). This shows that similar contact-induced variants may appear in various places simultaneously due to the typological properties of the languages involved – Arabic and Egyptian are both Afroasiatic languages – rather than automatically assuming geographical spread.

Indeed, many of the Egyptian-associated nonstandard features studied in this paper are in extensive use and seem to be part of the linguistic landscape for both L1 Egyptians as well as other L2 Greek users from various linguistic backgrounds (see Dahlgren 2016, 2017: 150–152). Contact varieties are born when there are enough L2 speakers in touch with the L1 population to make a difference; in some cases, the imperfectly learned variants start to spread even among native speakers, or a compromise of the two will start to form as the speech community's shared language (Thomason 2001: 74–75). Comparing Egyptian Greek to other contact varieties such as Indian English (cf. Dahlgren 2022) shows that there can be considerable variation in different regions and registers. Stress patterns fluctuate and vowel qualities differ, such as in the use of the famously Indian retroflex stops /t, d/ sometimes realized as the original British English alveolar stops (Sailaja 2012). Nevertheless, as a contact variety, it retains some elements which classify it as its own specific variety, differentiating it from other English varieties. In the same way, Egyptian Greek may also share elements with other Greek varieties, while still retaining its own recognizable set of features.

4.4 Co-occurrence of linguistic and non-linguistic variables

In the previous sections we looked at each non-linguistic variable in isolation. However, these variables are not independent of each other: to give a fictive example, the overrepresentation of variant *X* in place *Y* might simply be caused by the fact that there are many texts from the Byzantine period in place *Y* and that variant *X* is strongly associated with the Byzantine period (due to reasons of language change, for instance).

Therefore, we used multiple correspondence analysis (MCA) (see e.g., Glynn 2014 for a linguistic example) to better study the interaction between the different variables. Like MDS (see Section 3.1), correspondence analysis is a dimension reduction technique, plotting associations between different variables in a lower dimensional space. Like with MDS, when labels are close to each other on the plot, they show similar distributions. Figure 6 shows an MCA plot of the possibly Egyptian variants (i.e., the ones discussed in Sections 2 and 3) and the non-linguistic variables period, region and language, in addition to genre and material.¹³

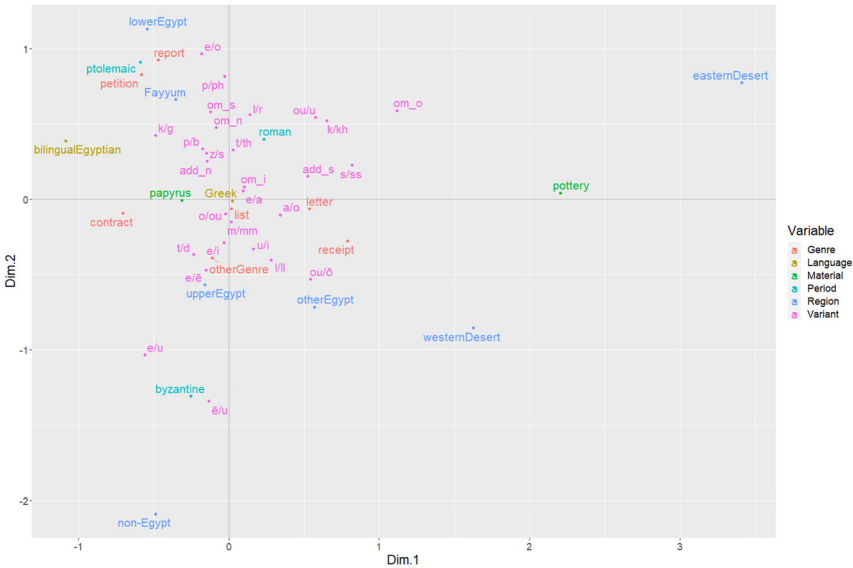


Figure 6: MCA plot of the Egyptian variables and non-linguistic variables.

¹³ The MCA was carried out with the function *MCA* in R package FactoMineR (Husson et al. 2020).

The MCA plot shows more complex relations between the variables discussed in Sections 4.1–4.3. For example, on the top left side of the MCA plot there is a tight cluster consisting of texts from the Ptolemaic period, bilingual Greek-Egyptian texts, texts from Lower Egypt or the Fayum and petitions and reports (as well as contracts, to some extent). Bilingual texts are a little less frequent in the Byzantine period (23.6% of all variants in bilingual texts occur in the Byzantine period, vs. 27.9% of all variants in monolingual texts). Therefore, variants that are both frequent in bilingual texts and the Byzantine period, such as /t, d/ and /e, u/, are particularly interesting. More importantly, bilingual texts are rather peculiar with regard to text type: in 67.8% of all cases where a spelling variant occurs in a bilingual text, the text is a contract (for monolingual texts, this is only 25.0%). This is not surprising, as contracts show their high occurrence of spelling variation in general (Stolk 2021) and it is known that professional scribes often had an Egyptian background, especially for the Ptolemaic period (Clarysse 1985; Vierros 2012: 39–49).

At the bottom of the plot, the label non-Egypt appears close to the label Byzantine. Inspecting the data, 62.6% of all variants in texts outside of Egypt come from the Byzantine period (on average this is 27.9%) and Ptolemaic texts are almost non-existent (only 0.5%, or 3 variants, vs. 12.0% on average). When investigating spelling variation outside Egypt, this chronological dimension therefore certainly needs to be taken into account.

Finally, on the right-hand side of the plot the factors *pottery* and *Eastern desert* (as well as *Western desert*, to a lesser extent) appear close to each other. These regions are rather peculiar: none of the variants appearing in texts from these regions are from the Ptolemaic period (200/350 of the variants from the Western desert and 1,041/1,046 of the variants from the Eastern desert are from the Roman period) and they show a high rate of texts written on pottery (1,017/1,046 variants, or 97%, for texts from the Eastern desert, and 192/350, or 55% for the Western desert, while on average only 12% of all variants occur on pottery). Neither region has any bilingual texts, explaining why they are plotted on opposite sides of the MCA plot (bilingual texts also appear on average less on pottery than monolingual texts – 7.4% of all variants vs. 12.3% respectively). The situation in the Eastern desert is particularly interesting, as it contains a large amount of texts written by Roman soldiers from different linguistic backgrounds (see Leiwo 2020). While this paper has focused on Egyptian-Greek transfer, the actual linguistic situation was of course considerably more complex, with Latin as another contact language in the Roman and Byzantine periods, although we have to leave the contact situation with Latin for further research.

5 Conclusions

We have used a new quantitative method to show correlations between spellings variants and their social context in the full corpus of Greek documentary papyri. This approach has allowed us to identify new linguistic and non-linguistic variables that would be relevant for the study of contact-induced spelling variation of Greek written in Egypt.

We started from a set of linguistic variables that had been argued in the scholarly literature to be affected by Egyptian phonological transfer. A multidimensional scaling of the usage contexts of these variables reveals that the association between the variant spellings <t, d> /t, d/, <k, g> /k, g/, <e, ē> /e, i/ and <o, ou> /o, u/ is very strong and the interchanges of <r, l> /r, l/, <s, z> /s, z/ and <e, a, o> /e, a, o/ also seem closely connected to this group. The variables <u, ou> /y, u/ and <p, b> /p, b/, on the other hand, do not typically co-occur in the same texts, which might suggest that they may have been used by a different group of writers than the other variants, or in a different social setting.

Several new variables also show a strong relation with the first group of features, some of them representing the same phonological transfer processes. The variation between back vowels /o, u/ may not only lead to variation of <o, ou>, but equally to <ō, ou>. The variation between front vowels and the underdifferentiation of /y/ could also explain the co-occurring variables <e, i> /e, i/, <i, u> /i, y/, <e, u> /e, y/. The omission of <o> and <i>, omission and addition of <s> and <n> and the variation between single and geminate consonants <l, ll>, <m, mm> and <s, ss>, on the other hand, have not been related to Egyptian phonological transfer before, but turn out to show a similar distribution to most of these other variables. Based on the phonological properties of Greek and Egyptian, it is possible to argue for some of these features that they would also have been likely to occur in the speech and writing of L1 Egyptian scribes. Thus, when taking a multi-causal approach to contact-induced change, Egyptian language contact may have been one of the factors enhancing the occurrence of these variables in the same texts with other Egyptian transfer features, while other factors, such as changes in the Greek language or variation due to contact with other languages, simultaneously may have had an impact as well.

Our second analysis allowed us to see whether the identified linguistic variables indeed typically co-occur in Egyptian-Greek contact situations. The variables first suggested in Dahlgren (2016) to belong to a pan-Egyptian contact Greek variety, <t, d>, <k, g>, <o, ou>, <e, o> and, in addition to those, <r, l> (to a lesser extent), turn out to be highly frequent in bilingual Egyptian-Greek documents. Out

of the new co-occurring variables, especially the variation between <e, u> also occurs in bilingual Greek-Egyptian documents more than average.

The variables are also highly chronologically dependent. The influence of Egyptian on Greek spelling variation has not been the same during these 1,000 years of Egyptian-Greek language contact. This may seem obvious, but perhaps due to the limited amount of information on the different stages of the Egyptian language, it is tempting to understand any signs of Egyptian phonological transfer that can be recovered from a certain text or subcorpus as common features for this contact variety, whereas in fact certain features turn out to be more typical for some periods than others. Examples of variants associated with the Ptolemaic period (III–I BCE) are <k, g>, <s, z> and <e, ē>, while e.g., the variation between <u, ou>, <l, r> and <a, e, o> correlates more closely with the Roman period (I–III CE). The variation between <e, a> continues in the Byzantine period, supplemented by <t, d>, <e, u> and <i, oi> and the (returning) variants <e, ē> and <s, z>. The findings correlate with Haugen's (1950) theory of the development of societal bilingualism and the “pre-bilingual period”, in which the first L2 users are particularly struggling with the foreign phonemes, stops and the beginning of iotacism, in the Ptolemaic period. Typically, the later generations learn to use the L2 more fluently with increased knowledge of it, as e.g., the Roman period Egyptian users of L2 Greek, with more phono-orthographic vowel variation partly related to the emergence of Coptic (see also Dahlgren 2017: 75–76; Haugen 1950). However, as most of the strongly Egyptian-related variables introduced above are associated with the Byzantine period (IV–VII), such as the variation between <t, d>, <o, ou>, <e, ē> and <e, u>, together they may represent the more fully established Egyptian Greek contact variety.

Our quantitative approach has allowed us to compare a large number of variables across a chronologically diverse corpus. This also means that our range of available variables was limited to what is currently available for this corpus and that we have only been able to discuss each of the variables very briefly in the space of this article. The correspondence analysis also showed that non-linguistic factors strongly interact, and therefore need to be interpreted with caution. Bilingual texts, for example, are less frequent in the Byzantine period and, most importantly, are rather peculiar genre-wise (most of them are contracts), which might influence the results. Even though Egyptian phonological transfer may be one of the factors that seem to connect these group(s) of features both linguistically and socially, many other linguistic and social factors may in fact have contributed to these spelling variants in individual cases. For example, some spelling variation might be related to specific linguistic communities, such as Roman soldiers in the Eastern desert, and transfer from languages other than Egyptian (e.g., from Latin) also needs to be taken into account.

Close reading of groups of texts from a similar social context would be helpful to establish in more detail which of the above-mentioned linguistic variables are most typical for each situation. Some of the most important contact-induced features are associated with genres, such as lists and receipts, and texts written on ostraca, especially during the Byzantine period. These are not typical sources for linguistic study and few of those have been used for this purpose, but they could offer particularly promising material for future studies of contact-induced variation in Egypt. By comparing all available data in the whole corpus at once, we hope to have been able to introduce a new method of studying the co-occurrence and distribution of spelling variation in historical sources as well as bring several new linguistic variables and new social contexts to the attention of future scholars of contact-induced variation in Egypt.

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