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Corpus-based Approaches to Grammar, Media and Health Discourses

Systemic Functional and Other Perspectives

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The M.A.K. Halliday Library Functional Linguistics Series

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The M.A.K. Halliday Library Functional Linguistics Series focuses on studies concerning the theory and application of Systemic Functional Linguistics (SFL). As a functional theory of language, SFL was initially developed by Professor M.A.K. Halliday and his colleagues in London during the 1960s, and since then its influence has spread all over the world.

Systemic Functional Linguistics distinguishes itself as a functional theory by the emphasis placed on system in relation to structure. It has also been particularly concerned with modelling language in context. The theory is especially well-known for the work on discourse analysis, cohesion, genre and register, appraisal and so on, which have been taken up by scholars working in other fields.

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Register Variation in Hellenistic Greek: Factor Analysis of Quantitative Linguistic Patterns

Stanley E. Porter and Ryder A. Wishart

1 Introduction and Background for This Study

Determining the contexts of ancient texts has long been an essential but particularly challenging task for researchers of ancient languages and cultures, notably within biblical studies. The notion that texts have something to tell us about ancient contexts has been widely understood for generations, and debate about just what these texts tell us about their settings has been a major component of scholarship in this area.

Form criticism within biblical studies, in particular, has served to advance this area of research. Form criticism, a methodology developed most prominently for New Testament studies (i.e. for Greek texts as opposed to ancient Semitic texts) by Karl Ludwig Schmidt (Kümmel 1973: 327–28), has long sought to unearth the *Sitz im Leben* ('setting in life') or situational context of ancient texts by considering the literary and linguistic patterns those texts exhibit. As these "forms" are identified and classified, they can then be peeled back, so to speak, exposing the original forms of the texts, thus allowing one to see more clearly their historical origins. As Muilenburg explains in his essay, "Form Criticism and Beyond," the basic assumption of the form critics is that ancient people "were influenced in their speech and their literary compositions by convention and custom. We therefore encounter in a particular genre or *Gattung* the same structural forms, the same terminology and style, and the same *Sitz im Leben*" (Muilenburg 1969: 4). In this study we assume this form-critical contention, that linguistic variation is inextricably tied to situational context, but we bring into question one of the fundamental assumptions of the form critics, namely that the basic unit of analysis useful for understanding a text's historical origin is the episode or literary section of a text ("pericope" in form-critical terminology [Muilenburg 1969: 2]).

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Previous analyses that have utilized similar data and method have been performed examining the systemic probabilities in Hellenistic Greek (see Porter and O'Donnell 2001), as well as examining the functional distribution of Hellenistic Greek within the New Testament (Porter 2000) and creating a specific application to the development of variation within the book of Romans (Porter and O'Donnell 2000). While examination of Romans provides an intra-book analysis, there has previously been no corpus-wide comparative basis available that could be used both to locate the book of Romans or any other book as a whole in relation to the extant Hellenistic Greek corpus, or to clarify whether patterns of variation within a book are rightly understood as register variation. This study is an initial attempt to provide that basis. In this chapter, we return to the book of Romans, but do so by analyzing not only its internal development but also how it compares to several wider corpora on a chapter-by-chapter basis and also section-by-section basis.

Our argument proceeds as follows. We first outline our corpora and methodology, along with baseline probabilities for each of the variables annotated in our data and some brief discussion on these probabilities. Next, we demonstrate how register variation can be observed and interpreted by examining patterns of morphosyntactic variation within the New Testament. Third, we demonstrate that this register variation is scalable from a smaller to a larger corpus. Fourth, we examine whether similar patterns of variation exist between different sub-sections of a single text, the book of Romans. If register patterns, which shift from text to text in a corpus, are evident and also shift from section to section of a text, then we would expect the same patterns to characterize the variation observed between sections of a text. If the patterns of variation between texts in a corpus did in fact characterize intra-text variation as well, then register variation (in many ways similar to, though perhaps more comprehensive than, the "stylistic variation" form critics look for) would be an appropriate tool for distinguishing sections of a text as the products of different historical circumstances. Based on our findings to the contrary, however, we argue that register is a characteristic of complete texts, not of sections, episodes, or pericopes within a text. Therefore, we make the case that differences in systemic probabilities characterize register variations when examined across texts in a corpus, not within individual texts. Finally, we summarize our results in a final section.

2 The Theory of Register in Systemic Functional Linguistics

Register is a concept developed within Systemic Functional Linguistics (SFL) in order to account for the fact that there is a non-random or predictable relationship between texts and their contexts (Matthiessen 2019; Lukin et al. 2011; O'Donnell 2000). More specifically, Halliday and Hasan (1985: 38) demonstrate that certain aspects of a context of situation (a semiotic model of a typical social situation within

a given cultural context) can be predicted from certain aspects of the text that realizes that situation.

Register accordingly holds promise for helping scholars better understand ancient texts whose situations are otherwise inaccessible. Since register is "a variety of language, corresponding to a variety of situation," linguistic patterns are a significant source of information about situational regularities (specifically their patterns of covariation, if not their precise situational parameters) (Halliday and Hasan 1985: 38).

This study aims to establish some of the baseline morphological probabilities evident in the extant linguistic data of Hellenistic Greek, with the goal of providing previously untapped information about average morphosyntactic values in this linguistic variety, the value of the New Testament as a representative corpus of Hellenistic Greek, and the major factors of register variation as they are reflected in realized probabilities.

3 Corpora, Methodology, and Baseline Probabilities

The corpora used in this study comprise the relatively structured but small corpus of the Greek New Testament, the set of available and morphologically annotated Greek papyri and ostraca, and approximately 380 Hellenistic Greek texts written between 400 BCE and 400 CE. For a description of the Hellenistic corpus and a breakdown by text, see Appendix 1. For a brief description of each corpus, see Table 1. While Celano (2018: 140) notes his corpus of papyri texts includes 62,901 documents, the XML files available online comprised only 34,308 files with ostensibly one document per file at the time the analysis was completed. We have included the Epistle to the Romans as a single-document corpus for comparing variation "below" the level of the text (i.e. the "chapter" or the "section").

Our data comprise traditional morphologically annotated texts in our three defined corpora. As such, we can only directly observe phenomena captured by this annotation. These phenomena include a morphologically and formally mixed set of forty-seven variables organized according to a number of larger systems or other traditional grammatical categories. These systems include: case (realized in our data as nominative, genitive, dative, accusative, and vocative), causality (active, middle, passive, and medio-passive), attitude (indicative, subjunctive, optative, imperative, infinitive, and participle, recognizing some of the limitations of these categories), gender (feminine, masculine, and neuter), aspect and other tense forms (aorist, present, imperfect, perfect, pluperfect, and future), number (singular, plural, and dual, recognizing that Atticistic texts from our period sometimes used the dual), and traditional parts of speech (pronoun, noun, interjection, verb, particle, conjunction, adverb, article, numeral, adjective, and preposition), and punctuation as a means of indicating the relative density of syntactical units.

Celano's unsupervised annotation of these various texts comprises an invaluable resource for corpus-based study of ancient Greek, though many limitations remain.

Table 1 Synopsis of corpora used in this study

Corpus	Number of works	Number of words (non-punctuation tokens)	Description
New Testament	27	137 K	Literary texts, personal letters, letters addressed to groups
Papyri and Ostraca	34,308	2.9 M	Formal and semi-formal non-literary texts, including official statements, contracts, receipts, personal letters, inscriptions on tombs and monuments, etc
Hellenistic Texts	380	9.41 M	Literary texts, including academic non-fiction such as geology and astronomy, as well as histories, letters, etc
Romans	1	7 K	Literary letter addressed to a group

For instance, the data are entirely morphological without analysis of syntactic units as seen in several other data sets [for example, see the Opentext.org Syntactically Annotated Greek New Testament (Land et al. 2016)]. The morphological analysis itself is based on the categories of traditional grammar, and thus, it includes a part-of-speech markup that is largely subjective, despite the formal nature of most of the other annotated variables. Some of the possible annotations are themselves highly problematic, such as the locative case, or the markup of the future perfect, which is variously understood depending on whether periphrastic constructions are included in this category or not. We have removed several categories from our analysis that are originally in Celano's data, including the locative, future perfect, and also the comparative and superlative properties (as these are derivational rather than inflectional, and furthermore these values are not adequately contrasted with the positive value, and thus a paradigmatic ratio for these properties is unhelpful). For each text in each corpus, the properties are grouped with their paradigmatically contrasting values (for example, all of the tense-form or voice values are grouped), counted by frequency, and then transformed into a ratio.

We define register as the systemic probabilities motivated or constrained by the context of situation giving rise to a text (Halliday and Hasan 1985: 38–39). Our method for register analysis involves principal component analysis, a statistical tool widely applied in social sciences as a means of reducing multivariate data to the point where it can be usefully interpreted. Principal component analysis forms one of the primary tools used in previous quantitative studies of register variation (Biber 1995: 85). Our analysis adopts a somewhat different approach from these studies, however,

insofar as we do not begin with a classification of various registers and then proceed to assess dimensions of variation between those categories. Rather, we make use of exploratory factor analysis on an uncategorized multivariate dataset in order to generate and interpret preliminary factors of register variation. We examine baseline probabilities for each of the corpora, examine patterns of variation between and within these corpora, and then postulate interpretive explanations of these patterns of variation. Thus, our study is a quantitative and synchronic analysis of register variation.

Using principal component analysis, one can determine the two (or more) major axes of variation characteristic of a data set. As Biber notes, "there is no mathematically exact method for determining the number of factors to be extracted" in an analysis (Biber 1995: 120). Because we have an essentially comparative question, however, we have restricted the analysis to two dimensions (and three dimensions in the case of a combination of all three corpora in the analysis of the papyri corpus). These axes are not indicated by any one property in the data but are indicative of underlying or "latent" factors that motivate the observable phenomena. In keeping with functional linguistic approaches in general, and SFL in particular, a likely interpretation of these underlying factors can be found in the parameters of the situations that gave rise to the texts.

The three situational parameters within SFL are identified as field, tenor, and mode. Within the field of biblical studies, most discussions that engage in this type of study revolve around questions of mode. Mode is typically conceived as a discussion of the organizing structures of a text, especially as these structures relate to the staged development of the text. In other words, mode is concerned with "how" a text is a text. Mode is therefore seen as in some sense the actualization of the other components of register, the means by which they are realized within a linear flow of text, in this case in the textual metafunction. Thus, there has been significant discussion of ancient epistolary structure in terms of the opening, body, and closing of such ancient letters. Within SFL discussion, epistolary organization has been developed along several different lines, including discussion of cohesion, cohesive harmony (see Land 2015; Reed 1997; Fewster 2013), and most recently generic structure potential (see Urbach and Land 2017). Register variation, despite the emphasis of previous research, is not confined to the structural emphasis of mode, but involves other components as well. In fact, mode provides the means by which the field and tenor components are activated and realized in text, and thus, it is worth exploring field and tenor in addition to mode.

The field of a text is concerned with "what" a text is about. The field of a text is realized in the ideational metafunction. The metafunctions within SFL comprise both semantic and lexicogrammatical strata. The lexicogrammar that realizes the field of a text involves especially such identifiable systems as verbal aspect realized by the tense forms, causality realized by the voice forms, and circumstances that indicate the spatial, temporal, and instrumental nature of clausal processes realized in Greek by, among other things, the dative case, adverbs, and prepositions. The tenor of a text is concerned with "who" is involved in a text. The tenor is realized in the interpersonal metafunction. The lexicogrammar that realizes the tenor of a text involves especially such identifiable systems as includedness realized by person and

number insofar as they correlate with each other, and the attitude system realized by mood forms. We recognize that there are a number of other systems that have varying degrees of related correlation with these systems, but these systems seem to be the strongest indicators of these contextual components (see Land 2015; Porter 2015).

The probabilities given in our data represent the average (mean) of each variable or property in each document in each of the analyzed corpora. The ratios do not add up to 100% in each case (though they generally will be close) because each number indicates the *average* ratio of, for example, accusatives in any given corpus (as opposed to the other features realizing case). Ratios are calculated in relation to the other possible features within their respective system; thus, for example, the ratio of singular is relative to plural and dual, and so on for each system.

This table of baseline probabilities (Table 2) is intended to serve, in conjunction with the principal axes of variation discussed throughout this chapter, as a reference for interpreting the findings of register analysis of Hellenistic Greek texts. In other words, using the findings presented in this chapter, one can better determine the significance of one's findings after analyzing a given Hellenistic Greek text using register analysis. Any given finding can be plotted first of all in relation to the overall morphosyntactic probabilities of each of the three corpora assessed here (though with some caveats mentioned in the next paragraph), and then considered in relation to the principal components of variation outlined below.

There are several important implications of this table of baseline probabilities. First, and most generally, it is clear that the New Testament as a corpus is not radically different from the Hellenistic corpus when juxtaposed with the papyri corpus. One of the ongoing limitations for most quantitative studies of New Testament Greek has been the challenge of collecting a representative corpus, since it has been assumed that the New Testament is not representative enough for drawing generalizations about the Hellenistic Greek language (see discussion in Pang 2016: 118–25; O'Donnell 2000). While there are differences across each of the corpora, some of them large, the New Testament appears to be an adequate corpus for drawing some generalizations about ratio values. To be clear, the use of inferential statistical analysis is still problematic due to the unclear nature of how well balanced these corpora are relative to an idealized notion of a balanced and representative corpus (Pang 2016: 125). The book of Romans can be seen to match the New Testament's ratios very closely (differing most significantly in the number system, which has a 4:1 ratio of singular to plural in Romans but a 3:1 ratio in the New Testament in general). Second, the papyri and ostraca corpus can be seen to have significantly different ratios in a number of systems. For example, it has far more genitives, with less nominatives and accusatives. The papyri corpus contains very few verbs with non-direct causation, as most of the medio-passive forms indicated in the annotation likely have no middle versus passive distinction in their paradigms. It also contains more aorists and perfects, but far fewer present tense forms. It has more nouns and adjectives than the other two corpora, but fewer verbs and adverbs, and, somewhat surprisingly, many more prepositions (not paralleled by an increase in dative forms as might be expected by the fact that the most frequent preposition from this period is ἐν, which

Table 2 Baseline probabilities for all corpora

	For Inter-text Analysis			For Intra-text Analysis	
	New testament	Hellenistic	Papyri	Romans (ch. mean)	Romans (actual)
Case					
Accusative	0.3	0.35	0.26	0.3	0.29
Nominative	0.3	0.3	0.18	0.31	0.31
Genitive	0.23	0.23	0.43	0.23	0.24
Dative	0.15	0.12	0.11	0.15	0.15
Vocative	0.01	0.01	0.01	0	0
Voice					
Medio.passive	0.13	0.18	0.35	0.11	0.11
Middle	0.07	0.06	0.03	0.08	0.08
Passive	0.15	0.14	0.03	0.16	0.16
Active	0.66	0.63	0.59	0.65	0.65
Mood					
Imperative	0.05	0.02	0.05	0.05	0.04
Participle	0.36	0.39	0.2	0.34	0.34
Indicative	0.44	0.39	0.45	0.47	0.48
Infinitive	0.09	0.15	0.12	0.08	0.08
Optative	0	0.02	0.03	0.01	0.01
Subjunctive	0.06	0.03	0.06	0.06	0.06
Gender					
Feminine	0.29	0.3	0.27	0.3	0.3
Masculine	0.54	0.45	0.57	0.5	0.51
Neuter	0.17	0.25	0.16	0.2	0.19
Tense form					
Future	0.04	0.03	0.03	0.05	0.05
Imperfect	0.03	0.05	0.03	0.02	0.02
Aorist	0.25	0.21	0.33	0.25	0.26
Perfect	0.05	0.06	0.19	0.04	0.04
Present	0.62	0.65	0.28	0.64	0.64
Pluperfect	0	0	0	0	0
Parts of speech					
Pronoun	0.09	0.06	0.03	0.08	0.08
Noun	0.21	0.19	0.3	0.22	0.23
Interjection	0	0	0	0	0
Verb	0.18	0.17	0.12	0.16	0.16

(continued)

Table 2 (continued)

	For Inter-text Analysis			For Intra-text Analysis	
	New testament	Hellenistic	Papyri	Romans (ch. mean)	Romans (actual)
Particle	0.03	0.06	0.04	0.06	0.06
Conjunction	0.06	0.05	0.02	0.05	0.05
Adverb	0.13	0.14	0.06	0.13	0.13
Article	0.07	0.07	0.06	0.07	0.07
Numeral	0	0	0.01	0	0
Adjective	0.09	0.11	0.15	0.08	0.08
Preposition	0.06	0.05	0.1	0.06	0.06
Punctuation	0.08	0.09	0.11	0.08	0.08
Number					
Singular	0.69	0.69	0.77	0.74	0.74
Plural	0.31	0.3	0.22	0.25	0.26
Dual	0	0	0	0	0
Person					
Second	0.18	0.09	0.12	0.17	0.15
Third	0.58	0.79	0.5	0.57	0.59
First	0.24	0.12	0.24	0.25	0.26

takes the dative case). Many of these prepositions are likely διά paired with genitive case forms, used in scribal attribution. The papyri have a 4:1 ratio of singulars to plurals as opposed to the 3:1 ratio of the other two corpora, but their ratio of person properties match the New Testament (the Hellenistic texts are likely skewed by numerous and lengthy treatises on medicine, etc., as noted below in the analysis of the Hellenistic corpus).

In the next section, we offer analyses of the various corpora using principal component analysis, and we seek to answer the question posed in our introduction: does intra-text variation mirror inter-text register variation?

4 Register Analysis

In his essay on "Quantitative Studies and Probabilities in Grammar," Halliday (1993/2005) describes register as a set of probabilities within the lexicogrammatical system of a language. Variation in register, in turn, can be described in terms of variation in systemic probabilities. By implication, a register can be analyzed, from the bottom up, in terms of probabilities within the language system as they are manifested in a corpus (i.e. the realizations of these systemic probabilities). A full description of register variation also requires a top-down analysis based upon

context of situation (and cultural context), but the probabilities nevertheless capture the realizations of those top-down parameters.

In the following sections, we offer principal component analyses and interpretation of these findings for each of our corpora. The New Testament patterns of variation are shown to be closely related to those of the larger Hellenistic corpus, but the papyri corpus exhibits divergence in one of its dimensions of variation, allowing a gradient but clear distinction between what one might call "literary" and "non-literary" texts.

For each analysis, we offer graphical representation of the results, both how the variables correlate with one another and the principal dimensions of variation, and also how the texts in each corpus, respectively, can be plotted in relation to those dimensions (for some analyses, we omit this latter visualization due to the high number of texts which render the graph unreadable). To perform these analyses and visualizations, we use the R packages, FactoMineR and Factoshiny (Lê et al. 2008). Each analysis is accompanied by a table describing the correlations of each property with the first and second principal components of variation. These correlations indicate which properties are strongly correlated (both positively and negatively) with their respective dimensions of variation.

4.1 Register Variation Across the New Testament

Here, we demonstrate how morphosyntactic variation can be observed and subsequently interpreted as register variation by examining patterns of variation within the New Testament. Two major axes of differentiation were identified for the New Testament corpus. We have interpreted these two axes on the basis of the properties that most highly correlate with them in a distribution across the data and concluded that these two axes capture the distinction between narratival versus expositional (dimension 1) and descriptive versus interactant (dimension 2) registers (Figs. 1 and 2).

The narratival versus expositional axis seen in dimension 1 ("Dim 1" on the graph) is a means of describing the orientation of the text toward either providing information or conveying an unfolding account and is correlated most closely with the field component of the context of situation. Those texts that are more narratival tend to have higher ratios of verbs, adverbs, numerals, indicatives, aorists, imperfects, pluperfects, masculines, and actives. Those texts that are more expositional tend to have nouns, prepositions, participles, presents, genitives, and feminines. In other words, all of the texts in the New Testament vary along this axis depending upon their relative ratios for each of the described variables. These variables correlate with variation along this axis (Table 3).

The second principal component indicated in dimension 2 for the New Testament captures the variation between descriptive versus interactant texts. This axis represents the orientation of texts toward the construal of the interactions that are encoded in the text and is correlated most closely with the interpersonal component of the context of situation, although recognizably along with some elements of field (e.g.,

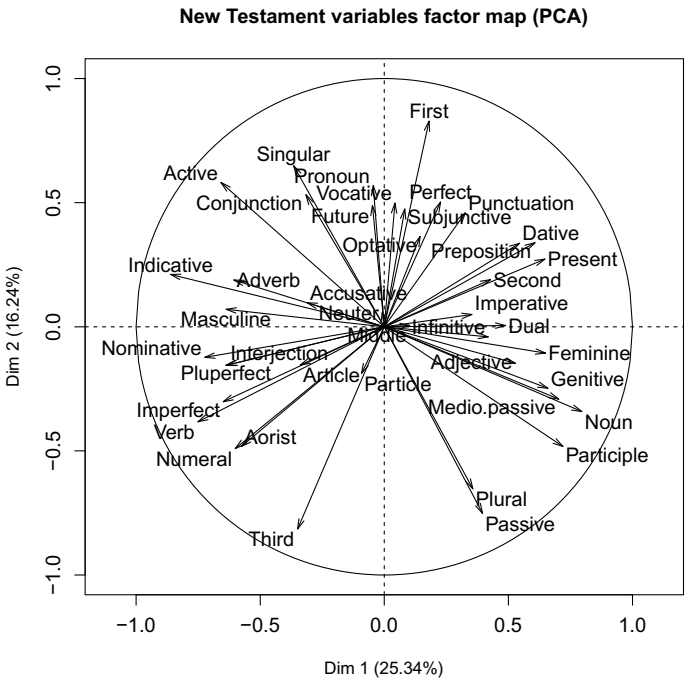

Fig. 1 New Testament variables factor map

causality). Those texts that are more descriptive tend to have higher ratios of third persons, passives, and plurals. Those texts that are more interactant tend to have first persons, actives, singulars, pronouns, and vocatives. As with the first axis, all of the texts of the New Testament vary along this axis also according to their relative ratios for each variable. To be clear, the texts of the New Testament vary along as many imaginable axes as there are variations between their wordings. However, principal component analysis identifies specifically those axes that account for the most variation in the data. Therefore, the texts of the New Testament vary most significantly in terms of these properties that correlate with the latent motivating situational factors. The result is essentially four quadrants of variation—though there are no firm lines of demarcation between these quadrants; all of the values are gradient. In the bottom-left quadrant, for example, one finds the Synoptic Gospels, Revelation, and Acts. In the top-right quadrant one finds Philemon, 2 and 3 John, and 2 Corinthians, among others.

In summary, the New Testament texts vary in their registers fundamentally in regard to how narratival versus expositional they are, and secondly in regard to how interactant versus descriptive they are. Next, we examine register variation across the Hellenistic corpus, to assess whether the New Testament register patterns are evident in a larger corpus.

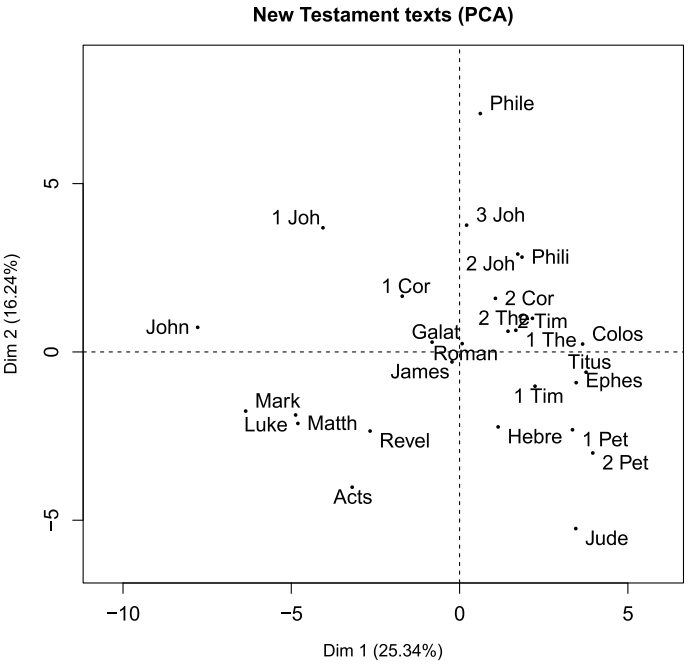

Fig. 2 Principal component analysis of New Testament texts

4.2 Register Variation Across Hellenistic Texts

In this section, we demonstrate that this register variation is scalable from a smaller to a larger corpus. For the Hellenistic Greek corpus, the dimensions of variation are generally similar to the New Testament but differ insofar as the Hellenistic corpus is entirely unstructured, as compared to the historically structured (and for all of that surprisingly balanced) New Testament corpus. In future work, a more balanced corpus would give a clearer picture of register variation that occurs in Hellenistic Greek. However, it is clear from the analysis of this corpus that the principal dimensions of variation in the Hellenistic texts can be interpreted very similarly to the New Testament dimensions. Some of the key areas of divergence from the New Testament analysis have to do with the fact that dimension 2 (interactant vs. descriptive) is less explanatory of variation in the Hellenistic corpus. This can be seen in that first, second, and third person do not correlate as strongly in dimension 2 in this corpus, as well as in the fact that passive and active voice are not equally correlated with dimension 2. What this discrepancy tells us is that the Hellenistic texts vary most significantly in terms of how narratival or expositional they are (dimension 1). Likely due to the unstructured nature of this corpus and the higher number of texts treating topics such as geometry, astrology, or medicine, the narratival versus expositional difference is far more significant in explaining the overall variation among all the

Table 3 Principal components (dimensions) of variation for New Testament corpus

Dimension 1	Correlation	Dimension 2	Correlation
Noun	0.8	First	0.83
Participle	0.72	Singular	0.65
Medio. passive	0.7	Active	0.58
Genitive	0.66	Pronoun	0.57
Feminine	0.65	Conjunction	0.53
Present	0.65	Perfect	0.5
Preposition	0.61	Vocative	0.5
Dative	0.54	Plural	−0.65
Adjective	0.53	Passive	−0.75
Aorist	−0.58	Third	−0.81
Numeral	−0.6		
Adverb	−0.61		
Interjection	−0.63		
Masculine	−0.64		
Pluperfect	−0.64		
Imperfect	−0.65		
Active	−0.66		
Nominative	−0.72		
Verb	−0.75		

texts. Nevertheless, the correlations observed between properties and their respective dimensions in this corpus are demonstrably similar to the dimensions of variation within the New Testament (Fig. 3; Table 4).

In summary, the Hellenistic texts, like the New Testament texts, vary most significantly according to how narratival versus explanatory they are and how interactant versus descriptive they are. This finding is significant insofar as the patterns of register variation in our smaller corpus map onto the larger corpus, strengthening the interpretation that these latent variables (i.e. the dimensions of variation) are indicative of patterns of variation in the parameters of the contexts of situation that gave rise to these texts, since patterns in the situational parameters realize the context of culture that gave rise to the texts in all three of our corpora. In the next section, we examine our corpus of papyri and ostraca and find a third dimension of variation.

4.3 Register Variation Across Papyri and Ostraca

For the papyri and ostraca corpus, the dimensions of variation are significantly different from the two previous corpora. This difference is signaled insofar as the properties

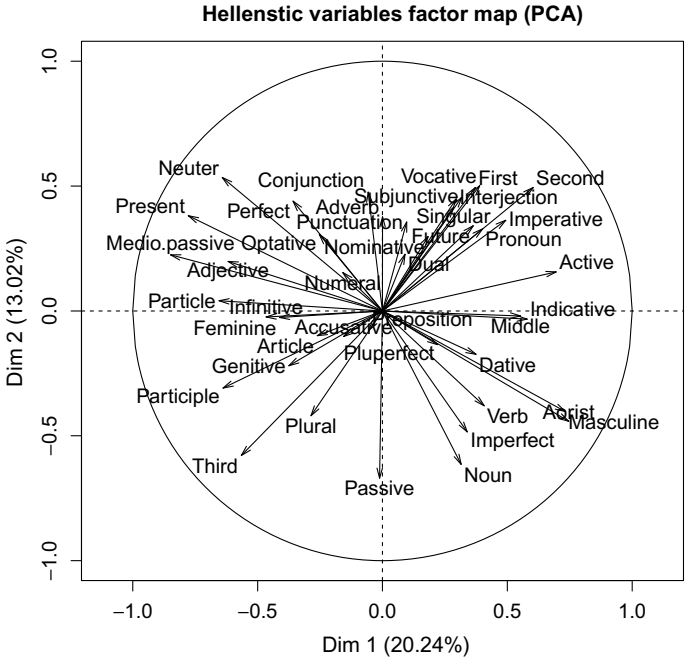

Fig. 3 Hellenistic variables factor map

that correlate with these principal components create different oppositions. Dimension 2 indicates the distinction between interactant versus descriptive as seen in the analyses above. Dimension 2 reflects the difference between third person forms and indicatives on the one hand, and second person forms, imperatives, and infinitives on the other. This distinction is similar to dimension 2 in the previous corpora with the added contrast between indicatives and imperatives. Dimension 1 is more difficult to classify as it does not follow the same line of variation as do the other corpora, which tend to contrast, among other variables, aorists and presents. In the papyri, presents contrast with perfects. Perfects tend to occur with ratios almost four times higher on average in the papyri corpus than in the other two corpora (as seen in Table 2). At the same time, dimension 1 records the distinction between process-oriented and entity-oriented texts, as seen in the contrast between verbs and adverbs versus nouns and adjectives. Upon inspecting papyri that fall on the extremes of this dimension, we noticed the noun–adjective–perfect combination represents (at least some of the time) the indication of scribal attribution and other signatories as well as prices, acknowledgments of local officials, the emperor, etc. (see the example of O. Stras 1.678 in Appendix 2, which has a negative 4.87 correlation with dimension 1). On the other extreme, CPR 5.20 (in Appendix 2), for example, has a positive 4.33 correlation with dimension 1, and it records interaction between siblings, requests for arrangements regarding relatives, possessions, and future correspondence. The

Table 4 Principal components (dimensions) of variation for Hellenistic corpus

Dimension 1	Correlation	Dimension 2	Correlation
Aorist	0.75	Neuter	0.53
Masculine	0.73	Vocative	0.5
Active	0.7	First	0.49
Second	0.6	Second	0.49
Indicative	0.58	Conjunction	0.48
Middle	0.55	Subjunctive	0.46
Imperative	0.49	Interjection	0.45
Verb	0.41	Perfect	0.44
Pronoun	0.4	Singular	0.41
Feminine	−0.41	Masculine	−0.4
Infinitive	−0.47	Plural	−0.42
Third	−0.57	Aorist	−0.44
Adjective	−0.62	Imperfect	−0.48
Participle	−0.64	Third	−0.58
Neuter	−0.64	Noun	−0.61
Particle	−0.65	Passive	−0.67
Present	−0.78		
Medio.passive	−0.85		

factors identified in dimension 1 for the papyri are more typical, we would argue, of non-literary texts.

We interpret dimension 1 for this corpus, therefore, as representing the difference between documentary and relational texts. On this dimension, documentary texts are essentially perfunctory records, cataloguing the economic and transactional affairs of everyday life, without developing an argument, storyline, or some other text-level configuration. The cohesion of documentary texts results from the adequate accounting of all details regarding the situation they function in that were perceived as noteworthy by the recorder (often a professional scribe). By contrast, relational texts will have a lower ratio of perfects overall by virtue of the fact that they tend to have far more verbs—especially presents, imperfects, and futures. Relational texts tend to convey a story or letter, often with an epistolary structure (Fig. 4; Table 5).

For a fuller analysis of the relevant variation, we combined approximately three hundred papyri (every hundredth text from the papyri corpus) with the Hellenistic texts (including the New Testament). The results of this analysis revealed the same primary axes of variation as the papyri corpus alone, which indicates that the Hellenistic (and New Testament) texts have more in common with one another than they do with most of the papyri texts (Fig. 5).

These results prompted us to examine the combined corpus from three dimensions, in order to compare the distribution of the three corpora over against the three major axes of variation they share. In this three-dimensional view, the x-axis approximates

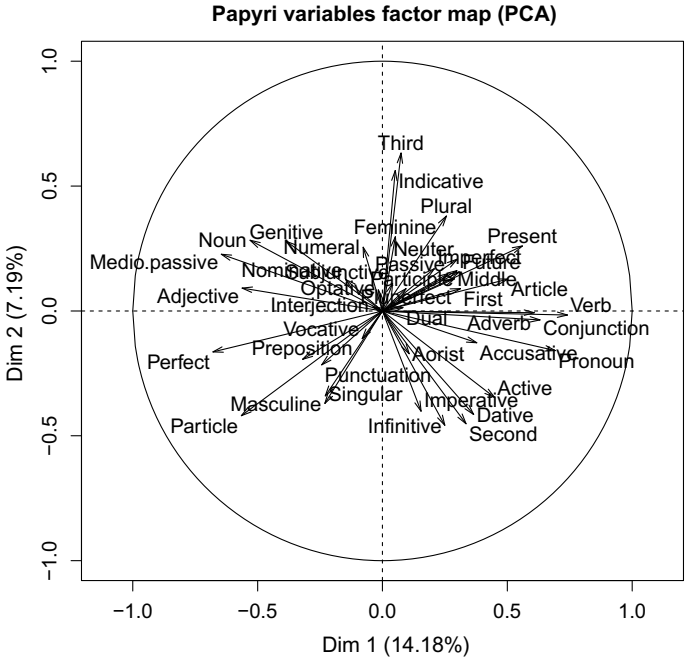

Fig. 4 Papyri and ostraca variables factor map

Table 5 Principal components (dimensions) of variation for Papyri corpus

Dimension 1	Correlation	Dimension 2	Correlation
Verb	0.74	Third	0.63
Pronoun	0.69	Indicative	0.56
Conjunction	0.63	Imperative	−0.4
Adverb	0.61	Dative	−0.41
Present	0.56	Particle	−0.42
Article	0.5	Second	−0.45
Active	0.45	Infinitive	−0.46
Noun	−0.53		
Adjective	−0.56		
Particle	−0.57		
Medio.passive	−0.65		
Perfect	−0.68		

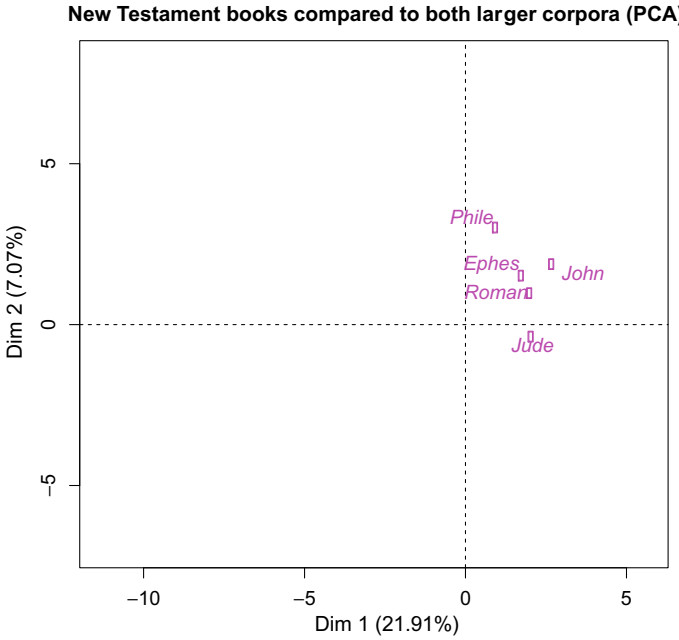

Fig. 5 Principal component analysis of New Testament texts within combined corpora of Hellenistic and papyri–ostraca texts

the variation of dimension 1 in the papyri corpus—the documentary versus relational distinction—and thus the Hellenistic (and New Testament) texts are all closely clustered apart from the majority of the papyri texts. Upon rotating the graph, however, the y-axis approximates much more closely the first dimension of variation for the Hellenistic texts—the narratival versus explanatory distinction. The *z*-axis in this three-dimensional graph approximated the interactant versus descriptive dimension which is evident with some variation across all three corpora (Figs. 6 and 7).

Based on this analysis, we would argue that the papyri are different from the other corpora in terms of their principal components because the variation among the papyri represents a different plane of variation than the other corpora. The papyri corpus exhibits divergence in one of its dimensions of variation (represented by the *x*-axis), and this divergence allows, we would argue, a gradient but clear distinction between literary and non-literary texts. The *y*- and *z*-axes comprise dimensions of variation among literary texts, and these dimensions are also evident among the papyri. However, the more fundamental axis of variation within the papyri corpus is the documentary versus relational distinction which, on the documentary end of the spectrum, comprises a greater distinction from the literary texts, which are, on this interpretation, more relational than documentary. The distinction between literary and non-literary is, according this reading of the data, a generic one that is borne out by this analysis of inter-textual morphosyntactic variation.

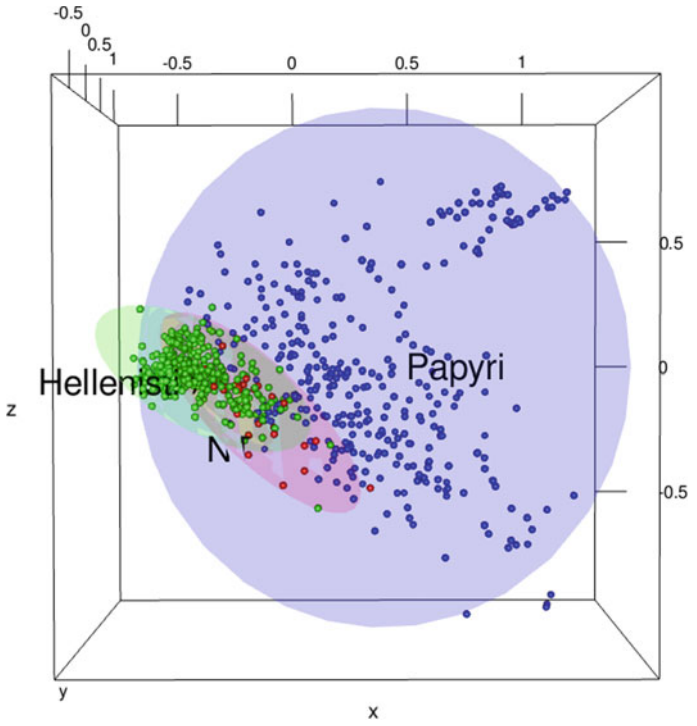

Fig. 6 Combined corpora with first (labeled *x*) and third (labeled *z*) factors of variation in focus

It is important to point out that there is a difference between the axis of variation (documentary vs. relational) and the generic distinction (literary vs. non-literary). The former reflects a distinction in register, or systemic probabilities correlated with distinct situational parameters. The latter is a generic distinction, where a *genre* is a staged, goal-oriented social process (Martin and Rose 2007: 8). However, this analysis indicates that the two kinds of variation are correlated. (In fact, they are often difficult to distinguish even terminologically. See Biber 1995: 9).

In summary, the papyri corpus is characterized by variation between documentary versus relational texts as well as interactant versus descriptive texts. We argue as well that the documentary versus relational distinction correlates with the generic distinction between literary and non-literary texts. Next, we examine whether similar patterns of register variation exist between different sub-sections of a single text, the book of Romans.

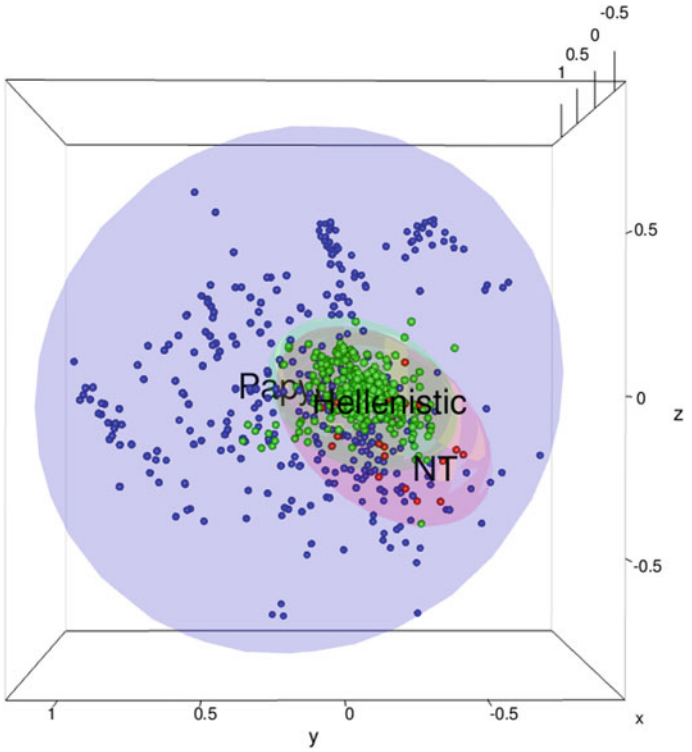

Fig. 7 Combined corpora with second (labeled *y*) and third (labeled *z*) factors of variation in focus

4.4 Patterns of Variation Across Paul's Epistle to the Romans

The purpose of analyzing the book of Romans on a chapter-to-chapter basis is to ascertain whether the register variation observable between different texts in a corpus is observable within a single text. Romans provides a useful opportunity for scaling down the level of analysis from full texts to text sections, that is, sections which are linearly integrated into a single text. The usefulness of Romans lies in the fact that it occupies the center point of variation within the New Testament, which is a structured subset of the larger corpus of Hellenistic texts. While Philemon, for example, has coordinates of 0.64 (dimension 1) and 7.10 (dimension 2) and Acts has—3.17 (dimension 1) and—4.00 (dimension 2), Romans has 0.10 (dimension 1) and 0.26 (dimension 2), placing it almost directly in the center of the New Testament graph.

If register patterns, which shift from text to text in a corpus, also shift from section to section in a text, then we would expect the same patterns to characterize the variation observed between sections of a text. If the patterns of variation between texts in a

corpus did in fact characterize intra-text variation, then register variation would be an appropriate tool for distinguishing sections of a text as the products of different historical circumstances. Based on our findings to the contrary, however, we argue that register is a characteristic of complete texts, not of sections, episodes, or pericopes within a text. Therefore, we make the case that differences in systemic probabilities characterize register variations when examined across—rather than within—texts in a corpus.

Analysis of the principal components of variation within the book of Romans, that is chapter-to-chapter variation, reveals variation somewhat similar to that observed within the papyri corpus. For example, dimension 1 in Romans contrasts indicatives and third persons versus imperatives and second persons, just as dimension 1 in the papyri corpus. At the same time, dimension 1 also contrasts singular and plural, which is consistent with dimension 2 in both the New Testament and Hellenistic corpora. In this way, chapter-to-chapter variation within Romans reflects both interactant versus descriptive morphosyntactic distinctions and also relational versus documentary features. We interpret this to indicate that chapters within Romans differ from one another according to their contribution to the semantic structure of the text, but this variation does not mirror the differences we can observe between discrete texts within a corpus. This asymmetry is, we argue, to be expected because the situational parameters do not change from chapter to chapter within a text in the same way as they change between different texts. Consider that different texts originate in contexts with distinct situational parameters. That is, different situations gave rise to these texts, and the differences between their respective situations could be described as differences in the field, tenor, and mode of these situations. These distinguishable field, tenor, and mode parameters in turn are probabilistically realized by linguistic patterns that occur across the entirety of the texts, respectively. *Within* a given text, however, the variation we observe from chapter to chapter cannot so simply be attributed to different contexts of situation, since the systemic probabilities of every clause in a given text, taken together, constitute the instantiation of the text's register, what Halliday calls "the cumulative force of the options taken up in the interpersonal [etc.] systems of meaning" (Halliday 1981/2002: 245) (Table 6; Figs. 8, 9 and 10).

It has been well recognized that certain chapters in Romans have more imperatives or indicatives and vice versa (see discussion in Gupta 2009), but this variation—evidenced in our own principal component analysis—is more similar to the variation observed between papyri than variation observed among literary texts. The dendrogram below captures the clustering of the various features chapter by chapter. This dendrogram based upon clusters of morphosyntactic features differs significantly from the dendrogram produced for Romans on the basis of clustering of semantic features (see Porter and O'Donnell 2000: 203).

What this divergence indicates is that texts that have very different semantic content might nevertheless exhibit similar morphosyntactic features that can be used to characterize register variation. Patterns of variation within a text are more indicative of the semantics of that text, its subject matter, content, and its patterns of argumentation than the register of the text and the situational parameters that the register implies. In other words, the topics treated in a given text are not indicative of the

Table 6 Principal components (dimensions) of variation for chapters of Romans

Dimension 1	Correlation	Dimension 2	Correlation
Indicative	0.77	Verb	0.75
Conjunction	0.72	Imperfect	0.64
Singular	0.7	Neuter	0.62
Particle	0.7	Present	0.59
Third	0.67	Active	0.53
Nominative	0.57	Dative	0.5
Subjunctive	0.55	Passive	−0.56
Future	0.54	Preposition	−0.6
Active	0.53	Dual	−0.68
Middle	−0.65	Aorist	−0.75
Second	−0.65	Genitive	−0.75
Plural	−0.7	Noun	−0.8
Adjective	−0.73		
Imperative	−0.74		

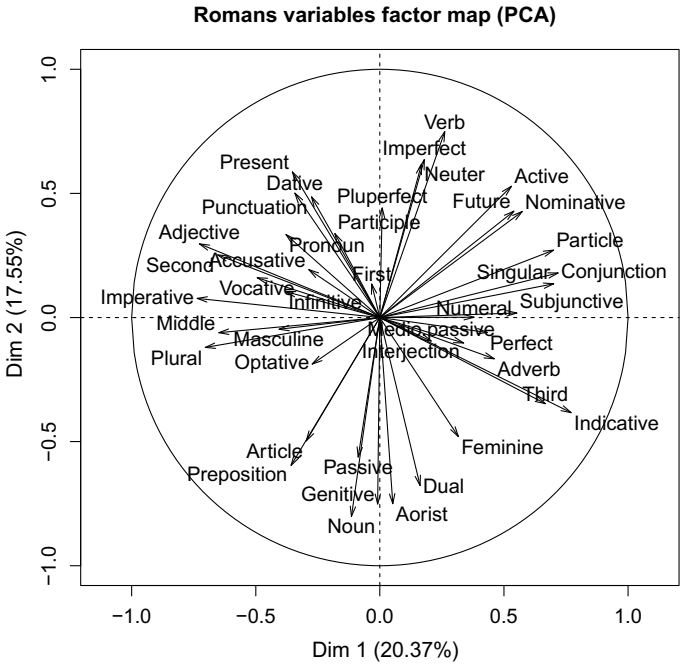

Fig. 8 Variables factor map for chapters of Romans

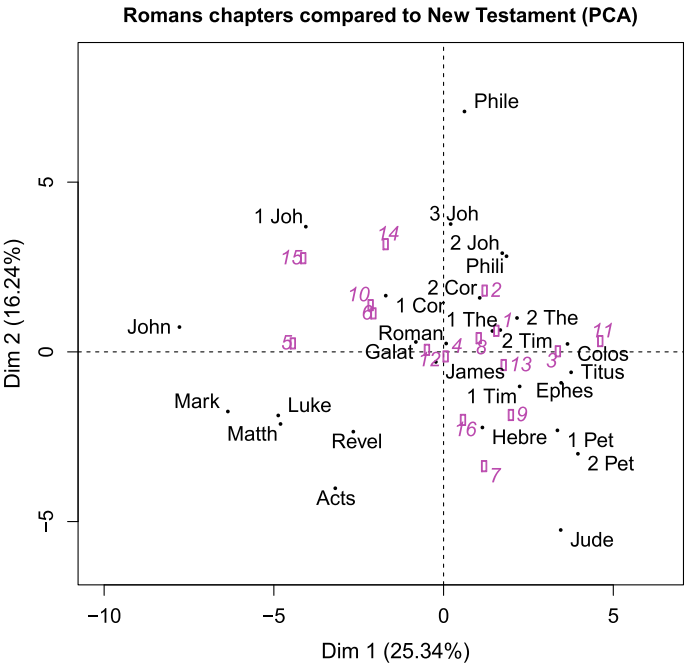

Fig. 9 Principal component analysis of New Testament texts with distribution of Romans chapters overlaid

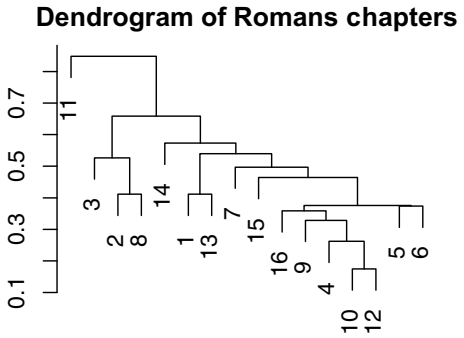

Fig. 10 Dendrogram of clustering between chapters of Romans based on similarity of morphosyntactic feature ratios in each chapter

sociolinguistic context giving rise to it so much as the modes of argumentation and other semantic features that make that text a unique instance of meaning. Register as a descriptor of a text is, by contrast, meaningful only intertextually, or between texts. The strongest fact in support of this argument is that the patterns of variation in a small corpus (the New Testament) are observable across a much larger corpus containing the smaller corpus (the Hellenistic texts, of which the New Testament is a part), but not within a single book of that smaller corpus (Romans).

Table 7 Principal components (dimensions) of variation for sections of Romans

Dimension 1	Correlation	Dimension 2	Correlation
Future	1	Article	0.99
Subjunctive	0.98	Dative	−0.91
Verb	0.97	First	−0.92
Conjunction	0.95		
Particle	0.93		
Adverb	0.91		
Active	0.91		
Adjective	−0.88		
Noun	−0.88		

One possible alternative explanation is that the chapter divisions in Romans are somewhat haphazardly determined (in part by formal, structural cues, and in a lesser part by literary considerations). Because these divisions tend to artificially fragment the text, the variation from fragment to fragment is more indicative of the kinds of variations observed among fragmentary papyri. In order to rule out this explanation as an objection to our larger argument, then, we divided Romans by literary (epistolary) sections, based on Porter and O'Donnell's previous study (2000: 177). When subjected to a principal component analysis as the other data sets, this set of section-to-section property ratios indicated a still more radical divergence from the above corpora (Table 7).

This analysis problematizes the idea that the variation from section to section of a text should be understood as register variation. One of the biggest differences between the sections of Romans is between those sections with futures and subjunctives (and, to a slightly lesser extent, verbs, conjunctions, etc.), and those sections, namely the opening and closing, that do not have futures, etc. The second dimension distinguishes the opening and closing. What these dimensions show is that, when analysis of variation is scaled down below the level of the text, the patterns of register variation essentially disappear and begin to be replaced, we would argue, with semantic and lexicogrammatical patterns of variation. The future is therefore 100% correlated with the body and parenesis of Romans, because it fits semantically with the "expectations" Paul is articulating in those sections. We see precisely the same shift toward specific semantics in the chapter-to-chapter variation observed above, specifically the strong distinction between indicatives and imperatives. (For coordinate tables and graphical representations of how the sections of Romans relate to each corpus, see Appendix 3).

The variation within Romans, then, is characterized by patterns of semantic or content shift, and differing modes of rhetorical argumentation, such as the indicative versus imperative distinction. Because the observed variation within Romans does not mirror the variation between texts in the larger corpora—though the latter hold across both a small corpus and a large one—we suggest that intra-book variation is characteristic of discourse patterns, especially variations in content, and not register variation as a realization of distinct situational parameters.

5 Summary of Results

The baseline probabilities yield several interesting points. It can be seen that the New Testament corpus bears strong similarity to the larger Hellenistic corpus as opposed to the papyri in terms of morphosyntactic ratios. Furthermore, the book of Romans—when taken as a whole—appears to represent almost perfectly the average morphosyntactic variation of the New Testament. The papyri and ostraca corpus differs more significantly from the other corpora, which we have attributed to the large number of non-literary documents it contains.

We interpret the variation within the New Testament and Hellenistic corpora to be most significantly characterized by the distinction between narratival versus explanatory texts. Secondarily, we have identified an interactant versus descriptive dimension. Together, these two latent factors capture a significant amount of the variation between texts in terms of systemic probabilities. These dimensions of variation are, we argue, indicative of different contexts of situation. Further research is needed in order to consider more fully the nature of those contexts and their parameters. According to our interpretation, however, some general features can be designated.

Narratival texts tend to be occupied with stringing together events, resulting in higher ratios of aorists, indicatives, and verbs. Explanatory texts tend to be occupied with more complicated arguments and explanations requiring expanded development of clause complexes, resulting in higher ratios of presents, participles, nouns, and adjectives. On the second dimension of variation, interactant texts directly involve the speaker and addressee (or author and reader), resulting in higher ratios of first and second persons. Interactant texts also tend to configure non-plural entities using direct causation, resulting in higher ratios of singulars and actives. Descriptive texts have a tendency to reverse these correlations, since they are occupied with describing entities that are not directly involved in the textual interchange.

We observed that the papyri are different from the other corpora in terms of their principal components, and we understood this divergence to indicate that variation among the papyri represent a distinct plane of variation between documentary versus relational texts. Documentary texts tend to be perfunctory, without text-level literary structures. Relational texts tend to convey, as we noted above, a story or letter, often with an epistolary structure (i.e. at least an opening, body, and closing).

A more detailed examination of the book of Romans allowed us to ascertain that patterns of variation within this text are not representative of cross-corpus variation. While the latter indicate changes in register, chapter-to-chapter and section-to-section variations within Romans is, we would argue, indicative of changes in content or modes of rhetorical argumentation, but not changes in register. Thus, we propose that variation within a single text is not an adequate indicator of changes in the situational context that gave rise to those various sections of text. In contrast to some forms of criticism that identify the "episode" within the text as the primary unit of critical analysis, our analysis suggests that register is best analyzed on the level of the text and not below that, whether that be the clause, the episode, the pericope, or

paragraph. Register then is realized in patterns of variation between texts as semantic units or objects of meaning (Halliday 1981/2002: 231).

6 Conclusion

In conclusion, we have offered an exploratory factor analysis of three corpora of Greek texts from the Hellenistic era. This analysis enabled us to form generalizations about some of the chief patterns of morphosyntactic variation within these texts. We have argued that these patterns are indicative of register variation, which realizes changes in the situational contexts that gave rise to each of the texts. Because these patterns are evidenced not only across our smaller corpus but also across our larger corpus, we believe they represent generalized situational parameters useful for characterizing these texts. At the same time, since these patterns are not reproduced through examination of the intra-textual chapters or sections of the generally balanced book, Romans, we have argued that situational parameters are realized by the ratios of entire texts, as semantic units, rather than portions of texts, which are components of those units. The papyri and ostraca in our third corpus introduce a third level of analysis, allowing for a gradient distinction between literary and non-literary texts. While more and better data will enable improvement upon these findings, we have nevertheless generated a baseline analysis of morphosyntactic probabilities across three corpora that will serve as a point of reference for future analysis, and also demonstrated that intra-text units, such as the episode or pericope—form criticism's "basic unit of analysis"—are not the correct unit of analysis for identifying situational parameters, since such units are not indicative of the patterns of register variation observed across multiple corpora.

Appendix 1: Breakdown of the Hellenistic Corpus by Text

The table in this appendix offers a summary of the documents from Celano's lemmatized corpus that fall within the range of the Hellenistic period, approximately 400 BCE to 400 CE (https://github.com/gcelano/LemmatizedAncientGreekXML). The names of authors and works and the word counts associated with each work have been generated from the metadata in Celano's texts, and thus many of the titles are in Latin, and some of the works have no associated author. The word counts, too, should be seen as approximate, as the data has in some cases not been edited. The texts of the New Testament corpus can be found below, as they form part (approximately 1.5%) of the Hellenistic corpus. The papyri and ostraca texts are too numerous for this format, but more information can be found in its associated paper (Celano 018) (Table 8).

Table 8 Summary of documents in Celano's data from target date range

Author	Work	Word count
Apollonius Rhodius	*Argonautica*	38,883
Plutarch	Theseus	7384
Plutarch	Romulus	9210
Plutarch	Comparison of Theseus and Romulus	1155
Plutarch	Lycurgus	9390
Plutarch	Numa	7504
Plutarch	Comparison of Lycurgus and Numa	1587
Plutarch	Solon	8464
Plutarch	Publicola	5840
Plutarch	Comparison of Solon and Publicola	940
Plutarch	Themistocles	7904
Plutarch	Camillus	11,042
Plutarch	Pericles	9940
Plutarch	Fabius Maximus	7710
Plutarch	Comparison of Pericles and Fabius Maximus	719
Plutarch	Alcibiades	10,041
Plutarch	Caius Marcius Coriolanus	9336
Plutarch	Comparison of Alcibiades and Coriolanus	1068
Plutarch	Timoleon	9050
Plutarch	Aemilius Paulus	9833
Plutarch	Comparison of Timoleon and Aemilius	478
Plutarch	Pelopidas	9409
Plutarch	Alexander	19,953
Athenaeus	*Deipnosophistae*	268,202
Athenaeus	*The Deipnosophists*	265,774
Herodian	*Ab excessu divi Marci*	46,884
Philo Judaeus	*De opificio mundi*	13,309
Philo Judaeus	*Legum allegoriarum libri i-iii*	32,372
Philo Judaeus	*De Cherubim*	7682
Philo Judaeus	*De sacrificiis Abelis et Caini*	9680
Philo Judaeus	*Quod deterius potiori insidiari soleat*	11,449
Philo Judaeus	*De Posteritate Caini*	11,220
Philo Judaeus	*De gigantibus*	3314
Philo Judaeus	*Quod deus sit immutabilis*	9103
Philo Judaeus	*De agricultura*	9081

(continued)

Table 8 (continued)

Author	Work	Word count
Philo Judaeus	*De plantatione*	9021
Philo Judaeus	*De ebrietate*	11,728
Philo Judaeus	*De sobrietate*	3678
Philo Judaeus	*De confusione linguarum*	10,671
Philo Judaeus	*De migratione Abrahami*	12,871
Philo Judaeus	*Quis rerum divinarum heres sit*	16,077
Philo Judaeus	*De congressu eruditionis gratia*	9054
Philo Judaeus	*De fuga et inventione*	11,200
Philo Judaeus	*De mutatione nominum*	13,461
Philo Judaeus	*De somniis (lib. i-ii)*	26,470
Philo Judaeus	*De Abrahamo*	13,370
Philo Judaeus	*De Josepho*	12,835
Philo Judaeus	*De vita Mosis (lib. i-ii)*	31,386
Philo Judaeus	*De decalogo*	8434
Philo Judaeus	*De specialibus legibus (lib. i-iv)*	56,870
Philo Judaeus	*De virtutibus*	12,393
Philo Judaeus	*De praemiis et poenis et De exsecrationibus*	9210
Philo Judaeus	*Quod omnis probus liber sit*	7616
Philo Judaeus	*De vita contemplativa*	4598
Philo Judaeus	*De aeternitate mundi*	9278
Philo Judaeus	*In Flaccum*	9056
Philo Judaeus	*Legatio Ad Gaium*	17,525
New Testament	Matthew	18,280
New Testament	Mark	11,263
New Testament	Luke	19,447
New Testament	John	15,583
New Testament	Acts	18,401
New Testament	Romans	7103
New Testament	1 Corinthians	6814
New Testament	2 Corinthians	4472
New Testament	Galatians	2230
New Testament	Ephesians	2419
New Testament	Philippians	1631
New Testament	Colossians	1579
New Testament	1 Thessalonians	1476

(continued)

Table 8 (continued)

Author	Work	Word count
New Testament	2 Thessalonians	823
New Testament	1 Timothy	1596
New Testament	2 Timothy	1244
New Testament	Titus	660
New Testament	Philemon	334
New Testament	Hebrews	4978
New Testament	James	1732
New Testament	1 Peter	1669
New Testament	2 Peter	1095
New Testament	1 John	2134
New Testament	2 John	243
New Testament	3 John	218
New Testament	Jude	456
New Testament	Revelation	9838
Galen	*Adhortatio ad artes addiscendas*	5037
Galen	*Protrepticus*	5085
Galen	*De optima doctrina*	1827
Galen	*Quod optimus medicus sit quoque philosophus*	1388
Galen	*De sectis ad eos qui introducuntur*	6214
Galen	*De constitutione artis medicae ad Patrophilum*	11,923
Galen	*Ars Medica*	16,110
Galen	*De elementis ex Hippocrate*	13,373
Galen	*De temperamentis*	27,606
Galen	*De temperamentis*	27,541
Galen	*De naturalibus facultatibus*	31,751
Galen	*De anatomicis administrationibus*	78,138
Galen	*De ossibus ad tirones*	6923
Galen	*De venarum arteriarumque dissectione*	7530
Galen	*De nervorum dissectione*	3599
Galen	*De instrumento odoratus*	4196
Galen	*De uteri dissectione*	3264
Galen	*De usu partium corporis humani I–XI*	193,348
Galen	*De motu musculorum*	14,652
Galen	*De victu attenuante*	6459
Galen	*De Victu Attenuante*	6426

(continued)

Table 8 (continued)

Author	Work	Word count
Galen	*De utilitate respirationis*	6041
Galen	*De semine*	20,736
Galen	*De foetuum formatione*	7683
Galen	*An in arteriis sanguis contineatur*	4696
Galen	*De optima corporis nostri constitutione*	1759
Galen	*De bono habitu*	818
Galen	*Quod animi mores corporis temperamenta sequantur*	8372
Galen	*De propriorum animi cuiuslibet affectuum dignotione et curatione*	8174
Galen	*De animi cuiuslibet peccatorum dignotione et curatione*	6312
Galen	*De atra bile*	6240
Galen	*De usu pulsuum*	4453
Galen	*De placitis Hippocratis et Platonis*	94,442
Galen	*De parvae pilae exercitio*	1687
Galen	*De parvae pilae exercitio*	1702
Galen	*De venereis*	395
Galen	*De venereis (ap. Oribasium)*	603
Galen	*De sanitate tuenda*	66,733
Galen	*De rebus boni malique suci*	10,138
Galen	*De ptisana*	2212
Galen	*De dignotione ex insomniis*	502
Galen	*De morborum differentiis*	6629
Galen	*De causis morborum*	6079
Galen	*De symptomatum differentiis*	6614
Galen	*De symptomatum causis*	29,386
Galen	*De differentiis febrium*	20,868
Galen	*De morborum temporibus*	5271
Galen	*De totius morbi temporibus*	3536
Galen	*De typis*	1578
Galen	*Adversus eos qui de typis scripserunt vel de circuitibus*	5596
Galen	*De plenitudine*	11,069
Galen	*De tremore, palpitatione, convulsione et rigore*	9104
Galen	*De comate secundum Hippocratem*	3243

(continued)

Table 8 (continued)

Author	Work	Word count
Galen	*De marcore*	5794
Galen	*De tumoribus praeter naturam*	4218
Galen	*De inaequali intemperie*	3157
Galen	*De difficultate respirationis*	31,776
Galen	*De locis affectis*	69,688
Galen	*De pulsibus ad tirones*	5974
Galen	*De differentiis pulsuum*	42,725
Galen	*De dignoscendis pulsibus*	31,107
Galen	*De causis pulsuum*	31,956
Galen	*De praesagitione ex pulsibus*	36,201
Galen	*Synopsis librorum suorum de pulsibus*	15,687
Galen	*De crisibus*	33,775
Galen	*De diebus decretoriis*	27,171
Galen	*De methodo medendi*	157,041
Galen	*Ad Glauconem de methodo medendi*	22,849
Galen	*De venae sectione adversus Erasistratum*	5971
Galen	*De venae sectione adversus Erasistrateos Romae degentes*	9024
Galen	*De curandi ratione per venae sectionem*	10,037
Galen	*De hirudinibus, revulsione, cucurbitula, incisione et scarificatione*	703
Galen	*De purgantium medicamentorum facultate*	2971
Galen	*Quos quibus catharticis medicamentis et quando purgare oporteat*	1991
Galen	*Quos quibus catharticis medicamentis et quando purgare oporteat (ap. Oribasium)*	2001
Galen	*Pro puero epileptico consilium*	3216
Galen	*De simplicium medicamentorum temperamentis ac facultatibus I–VI*	133,500
Galen	*De compositione medicamentorum secundum locos I–VI*	143,002
Galen	*De compositione medicamentorum per genera*	104,026
Galen	*De antidotis*	27,824
Galen	*De theriaca ad Pisonem*	13,020

(continued)

Table 8 (continued)

Author	Work	Word count
Galen	*Institutio logica*	8613
Galen	*De sophismatis seu captionibus penes dictionem*	2530
Galen	*De praenotione ad Epigenem*	11,020
Galen	*De substantia facultatum naturalium fragmentum*	1370
Galen	*In Hippocratis De natura hominis*	24,375
Galen	*In Hippocratis De victu acutorum*	67,010
Galen	*In Hippocratis Epidemiarum I*	155,958
Galen	*In Hippocratis Aphorismos*	95,828
Galen	*Adversus Lycum*	7419
Galen	*Adversus ea quae Juliano in Hippocratis Aphorismos enuntiata sunt*	7577
Galen	*In Hippocratis De articulis*	61,370
Galen	*In Hippocratis Prognosticum*	42,799
Galen	*In Hippocratis De fracturis*	41,589
Galen	*In Hippocratis De officina medici*	41,027
Galen	*De musculorum dissectione ad tirones*	14,730
Galen	*De consuetudinibus*	3996
Galen	*De experientia medica*	999
Galen	*De causis respirationis*	675
Lucianus Samosatenus	*Cataplus*	4037
Lucianus Samosatenus	*Juppiter confutatus*	2320
Lucianus Samosatenus	*Juppiter tragoedus*	6712
Lucianus Samosatenus	*Gallus*	5728
Lucianus Samosatenus	*Prometheus*	2390
Lucian	*Prometheus*	2375
Lucianus Samosatenus	*Icaromenippus*	5310
Lucianus Samosatenus	*Timon*	6068
Lucianus Samosatenus	*Charon sive contemplantes*	4242
Lucianus Samosatenus	*Vitarum auctio*	3659
Lucianus Samosatenus	*Revivescentes sive piscator*	6453
Lucianus Samosatenus	*Bis accusatus sive tribunalia*	5766
Lucianus Samosatenus	*De sacrificiis*	1803
Lucian	*De sacrificiis*	1786

(continued)

Table 8 (continued)

Author	Work	Word count
Lucianus Samosatenus	*Adversus indoctum et libros multos ementem*	3834
Lucianus Samosatenus	*Somnium sive vita Luciani*	1817
Lucianus Samosatenus	*De parasito sive artem esse parasiticam*	6566
Lucianus Samosatenus	*Philopseudes sive incredulus*	6400
Lucianus Samosatenus	*Dearum judicium*	2071
Lucianus Samosatenus	*De mercede conductis potentium familiaribus*	7127
Lucianus Samosatenus	*De morte Peregrini*	4281
Lucianus Samosatenus	*Fugitivi*	3227
Lucianus Samosatenus	*Toxaris vel amicitia*	9831
Lucianus Samosatenus	*De saltatione*	7071
Lucianus Samosatenus	*Lexiphanes*	2899
Lucianus Samosatenus	*Eunuchus*	1324
Lucianus Samosatenus	*De astrologia*	2005
Lucianus Samosatenus	*Pseudologista*	3944
Lucianus Samosatenus	*Deorum concilium*	1865
Lucianus Samosatenus	*Tyrannicida*	2922
Lucianus Samosatenus	*Abdicatus*	4789
Lucian	*Dialogi Marini*	4118
Arrian	*Anabasis*	78,474
Arrian	*Indica*	13,762
Arrian	*Cynegeticus*	5974
Arrian	*Periplus Ponti Euxini*	4346
Arrian	*Tactica*	8996
Arrian	*Acies Contra Alanos*	1255
Apollonius, Dyscolus	*De constructione*	60,280
Agathemerus	*Geographiae Informatio*	1978
Theophrastus	Characters	6724
Nichomachus of Gerasa	*Introductio arithmetica*	24,329
Nicomachus Gerasenus	*Problemata arithmetica*	1180
Claudius Ptolemaeus	*Syntaxis mathematica*	171,408
Claudius Ptolemaeus	*Apotelesmatica (= Tetrabiblos)*	38,446
Pausanias	Description of Greece (Greek).	218,178
LXX	Genesis	32,166
LXX	Exodus	24,431

(continued)

Table 8 (continued)

Author	Work	Word count
LXX	Leviticus	18,897
LXX	*Numeri*	24,733
LXX	*Deuteronomium*	22,301
LXX	*Josue*	14,599
LXX	*Judices (Cod. Alexandrinus)*	15,531
LXX	Ruth	1985
LXX	*Regnorum i (Samuelis i in textu Masoretico)*	19,672
LXX	The Old Testament in Greek	17,690
LXX	*Regnorum iii (Regum i in textu Masoretico)*	20,271
LXX	*Regnorum iv (Regum ii in textu Masoretico)*	18,296
LXX	Ecclesiastes	19,859
LXX	*Isaias*	151,988
Pseudo-Galen	*De fasciis*	8057
Pseudo-Galen	*Ad Gaurum quomodo animetur fetus*	9929
Pseudo-Galen	*Introductio seu medicus*	18,821
Pseudo-Galen	*De remediis parabilibus*	35,376
Pseudo-Galen	*De theriaca ad Pamphilianum*	2148
Pseudo-Galen	*De optima secta ad Thrasybulum*	17,409
Pseudo-Menander	*Sententiae* (corresponds to version Men Ar I) (Greek)	2807
Pseudo-Menander	*Sententiae* (corresponds to version Men ar II) (Greek)	573
Pseudo-Menander	*Sententiae* (corresponds to quotes from Gregory Nazianzen, Carmen morale XXX) (Greek)	144
Polybius	Histories	313,278
Sextus Empiricus	*Pyrrhoniae hypotyposes*	52,538
Sextus Empiricus	*Adversus mathematicos*	109,815
Apollodorus	Library	27,259
Apollodorus	Epitome	7890
Appian	Kings	797
Appian	Italy	1083
Appian	Samnite History	3413
Appian	Gallic History	2061
Appian	Sicily and the Other Islands	922

(continued)

Table 8 (continued)

Author	Work	Word count
Appian	Wars in Spain	15,983
Appian	Hannibalic War	9662
Appian	Punic Wars	25,069
Appian	Numidian Affairs	362
Appian	Macedonian Affairs	3598
Appian	Illyrian Wars	4836
Appian	Syrian Wars	13,678
Appian	Mithridatic Wars	24,008
Appian	The Civil Wars	117,058
Artemidorus	*Onirocriticon*	64,262
Chariton	*De Chaerea et Callirhoe*	35,178
Clement of Alexandria	*Protrepticus*	23,501
Clement of Alexandria	*Paedagogus*	57,808
Clement of Alexandria	*Stromata*	28,680
Clement of Alexandria	*Eclogae propheticae*	5042
Clement of Alexandria	*Quis dives salvetur*	9267
Clement of Alexandria	*Excerpta ex Theodoto*	7606
Longus	*Daphnis & Chloe*	19,794
Soranus	*Gynaeciorum Libri IV*	42,454
Soranus	*De Fasciis*	2955
Soranus	*Vita Hippocratis Secundum Soranum*	700
Dio Chrysostom	*Orationes*	178,576
Babrius	*Fabulae Aesopeae*	11,504
	Commentaria in Aristotelem Graeca	69,726
Polyaenus	*Strategemata*	63,456
Polyaenus	*Excerpta Polyaeni*	16,484
Alciphron	*Epistulae*	20,842
	Supplementum Aristotelicum	409
Anonymus Londinensis	*Iatrica*	13,132
Anonymus Londinensis	*Fragmenta*	160
Justinus Martyr	*Apologia*	14,462
Justinus Martyr	*Apologia Secunda*	3291
Justin Martyr	*Apology II*	3291
Justinus Martyr	*Dialogus cum Tryphone*	55,929
Pseudo-Justinus Martyr	*Epistula ad Diognetum*	2612
Heliodorus of Emesa	*Aethiopica*	76,370

(continued)

Table 8 (continued)

Author	Work	Word count
Polyaenus	*Polyaeni Strategematon Libri Octo*	63,456
Polyaenus	*Excerpta Polyaeni*	16,484
Ammonius Grammaticus	*De adfinium vocabulorum differentia ΠΕΡΙ ΟΜΟΙΩΝ ΚΑΙ ΔΙΑΦΟΡΩΝ ΛΕΞΕΩΝ*	17,388
Alexander of Aphrodisias	*In Aristotelis metaphysica commentaria*	335,706
Alexander of Aphrodisias	*In Aristotelis analyticorum priorum librum I commentarium*	155,049
Alexander of Aphrodisias	*In Aristotelis topicorum libros octo commentaria*	182,046
Alexander of Aphrodisias	*In Librum De* Sensu *Commentarium*	50,887
Alexander of Aphrodisias	*In Aristotelis Meteorologicorum Libros Commentaria*	84,268
Alexander of Aphrodisias	*Quaestiones*	3624
Alexander of Aphrodisias	*In Aristotelis Sophisticos Elenchos Commentarius [Sp.]*	71,937
Anubion	*Fragmenta*	84
Athenagoras	*Legatio sive Supplicatio pro Christianis*	11,304
Athenagoras	*Supplication pro Christianis*	11,301
Athenagoras	*De Resurrectione*	8816
Athenagoras	*De resurrectione*	8912
Barnabas	*Barnabae epistula*	6714
	Batrachomyomachia	2146
	Certamen Homeri et Hesiodi	2616
Clemens Romanus	*Epistula I ad Corinthios*	9827
Clemens Romanus	*Epistula II ad Corinthios*	3013
Anonymus	*Didache XII Apostolorum*	2191
	Fragmenta alia antiqua	689
Harpocration, Valerius	*Lexicon in decem oratores Atticos*	38,977
Hermas, 2nd cent.	The Shepherd of Hermas	28,659
Ignatius Antiochenus	*Ad Ephesios (epist. 1)*	1773
Ignatius Antiochenus	*Ad Magnesios (epist. 2)*	1055
Ignatius Antiochenus	*Ad Trallianos (epist. 3)*	951
Ignatius Antiochenus	*Ad Romanos (epist. 4)*	1021
Ignatius Antiochenus	*Ad Philadelphios (epist. 5)*	1017
Ignatius Antiochenus	*Ad Smyrnaeos (epist. 6)*	1146

(continued)

Table 8 (continued)

Author	Work	Word count
Ignatius Antiochenus	*Ad Polycarpum (epist. 7)*	787
Irenaeus	*Libros quinque adversus haereses*	21,721
Enoch	Enoch	12,673
	Martyrium Polycarpi	2648
	Maximi et Ammonis carminum de actionum auspiciis reliquiae	4024
	Maximi et Ammonis carminum de actionum auspiciis reliquiae (epitome)	2471
	DIE ORACULA SIBYLLINA	28,250
	DIE ORACULA SIBYLLINA	645
Philostratus the Lemnian (Philostratus Major)	*Imagines*	23,098
Polycarp	*Epistula ad Philippenses*	1585
Testamentum Abrahamae	The Testament of Abraham Recension A	6972
Testamentum Abrahamae	The Testament of Abraham Recension B	3230
Theon Smyrnaeus	*De utilitate mathematicae*	38,126
Theophilus	*Ad Autolycum*	21,610
Dionysius Antiochenus	*Ad Autolycum*	21,571
	Vita Aesopi Pl vel Accursiana (sub auctore Maximo Planude)(recensio 1)	11,760
Vitae Aesopi	*Vita Aesopi (fort. auctore Aphthonio)*	306
Aesop	Βιβλίον μυθικὸν τοῦ Αἰσώπου	158
Tatianus	*Oratio ad Graecos*	10,226
Euclid	Elements	146,664
Euclid	Data	19,279
Euclid	Data (*demonstrationes alterae*)	4237
Plotinus	*Enneades*	214,096
Iamblichi	*Protrepticus*	26,194
	COMENTARIA IN ARISTOTELEM GRAECA	10,871
	COMENTARIA IN ARISTOTELEM GRAECA	30,097
Porphyry	*Quaestionum Homericanum ad Iliadem pertinentium reliquiae*	67,848
Porphyry	*Zetemata codicis Vaticani*	12,357
Origenes	*Contra Celsum*	166,073

(continued)

Table 8 (continued)

Author	Work	Word count
Origenes	*Commentarii in Evangelium Joannis*	155,442
Origenes	*Fragmenta In Evangelium Joannis (In Catenis)*	23,203
Origenes	*Exhortatio ad martyrium*	12,541
Origenes	*De oratione*	28,446
Origenes	*In Jeremiam (Homiliae 1–11)*	24,538
Origenes	*Fragmenta In Jeremiam*	8574
Origenes	*Fragmenta In Lamentationes (In Catenis de Prophetis)*	10,788
Origenes	*Fragmentum in Lamentationes (In Catenis de Octateucho)*	172
Origenes	*De Engastrimytho*	3588
Origenes	*Fragmenta in Librum Primum Regnorum (In Catenis de Samuelis et Regnorum)*	1973
Origenes	*Fragmentum In Librum Primum Regnorum (In Catenis de Cantico Canticorum)*	90
Origenes	*Homiliae In Lucam*	47,726
Origenes	*Fragmenta In Lucam*	15,007
Origenes	*In Jeremiam (Homiliae 12–20)*	31,356
Origenes	*Commentariorum Series In Evangelium Matthaei*	81,276
Origenes	*Commentarium In Evangelium Matthaei (Lib. 10–11)*	22,169
Origenes	*Commentarium In Evangelium Matthaei (Lib. 12–17)*	130,199
Origenes	*Epistula ad Africanum*	4716
Origenes	*Fragmenta In Jeremiam (E Philocalia)*	756
Hippolytus	Works	70,078
Hippolytus	*Refutatio Omnium Haeresium*	69,505
Gorgias	Encomium of Helen	1327
Gorgias	Defense of Palamedes	2426
	Apotelesmatica	19,969
Methodius	*Symposium Sive Convivium Decem Virginum*	28,504
Methodius	*De Libero Arbitrio*	10,595
Methodius	*De Creatis (Fragmenta Ap. Photium, Bibl. Cod. 235)*	1864

(continued)

Table 8 (continued)

Author	Work	Word count
Methodius	*Adversus Porphyrium (Fragmenta)*	1215
Methodius	*Fragmenta In Job (In Catenis)*	1596
Methodius	*De Martyribus (Fragmenta)*	57
Methodius	*Fragmenta Incerta [Sp.]*	143
Total		9,411,329

Appendix 2: Example Papyri

These example papyri can be found at Papyri.info along with full explanation of transcription and markup conventions. These examples occupy extremes along dimension one of the papyri corpus. O.Stras 1.678, an ostracon recording economic transactions, has a negative 4.87 correlation with dimension one, making it an example of the documentary end of the documentary versus relational axis. CPR 5.20, a papyrus letter, has a positive 4.33 correlation, making it an example of the relational end.

O.Stras 1.678 (Second century (uncertain))

λόγ(ος) Φαρ(μοῦθι).

Ὥρου απο. υπ( ) εἰς χω( ) κ̣αὶ τη[-ca.?-]

Φαρ(μοῦθι) η ἄ(ν)δ(ρες) δ ἐ(κ) (δραχμῶν) β . [-ca.?-]

θ ἄνδ(ρες) ϛ ἐ(κ) (δραχμῶν) β, πα(ῖ)δ(ες) [-ca.?-]

5ι ἄνδ(ρες) ια ἐ(κ) (δραχμῶν) β [-ca.?-]

[-ca.?-] ἄνδ(ρες) ια ἐ(κ) (δραχμ) [-ca.?-]

[-ca.?- ἄ]νδ(ρες) α̣[.]

CPR 5.20 (Third–fourth century (uncertain))

recto

Χερήμων Εὐδαίμονι ἀδελφῷ̣ \χ(αίρειν)./

καλῶς ποιήσις, ἄδελφαι, τέ-

λιαν τὴν εὐποιγιανσου ἀπο-

δῖξαι καὶ πρὸς ὃ βλέπις. τὴν

5ἀδελφὴν ἡμῶν, ἠὰν ἦν μό-

νη, πᾶν ποίησον πέμψε αὐτὴν

μετὰ τῆς μητρός σου, ὶ δὲ οὐ,

ἐν σοὶ γενέστω. καὶ πρὸς τὸ συν-

φέρων ἀντίγραψόν μοι. βίασε

10δὲ τοῦ αὐτὴν πέμψε ἐν Ἀλεξανδρί-

α̣, ἠὰν δὲ ἴδῃς ὅτι ἀηδίαν ἔχι καὶ

οὐ δύνατε, ἀντιγράψατέ μοι

. . . τ̣έλιά̣ν σ̣ρ̣υ̣ τὴν εὐποιγιαν

ἀ̣[π]ο̣δ̣ι̣[. . .]. [- ca.10 -].

-- -- -- -- -- -- -- -- -- --

16-- -- -- -- -- -- -- -- -- --

15[. . . . .]. . [-ca.?-]

[. . . . .]. . . [.]. . . . [.]

[. .]. ῃσο̣υ̣. . vac. ?

ἀσπάζομέ σε καὶ τὴν σύνβιόν

σου καὶ τοὺς σοὺς πάντας.

20τὰ ἀντίγραφά μοι ταχὺ πέμψον

παρὰ τὸν πατέρα σου.

(hand 2) ἐρρῶσθαί σε εὔχομαι.

verso

. . . . [. .]. [. .]. . . . vac. ? . . . . [vac. ?(?)] π̣(αρὰ) Χερήμο̣νο̣ς . . . .

Appendix 3: Sections of Romans Related to Each Corpus

This appendix contains maps and tables specifying exact coordinates of how the five sections of Romans are distributed within each of the three corpora used in this study. The tables indicate how far above or below the axis each section falls for each dimension. For example, the opening of Romans scores 9.18 on the first dimension of variation, represented by the *x*-axis in Fig. 11.

See Figs. 12 and 13; Tables 9, 10, and 11

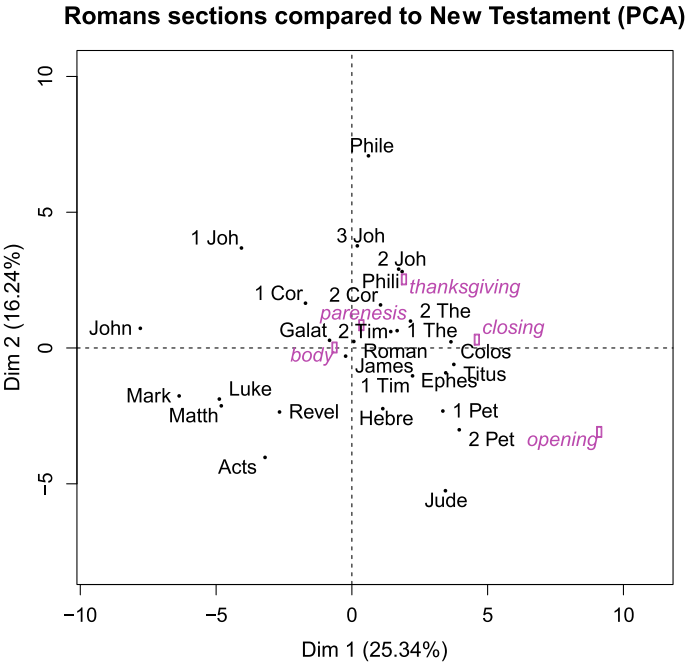

Fig. 11 Principal component analysis of New Testament texts with distribution of Romans sections overlaid

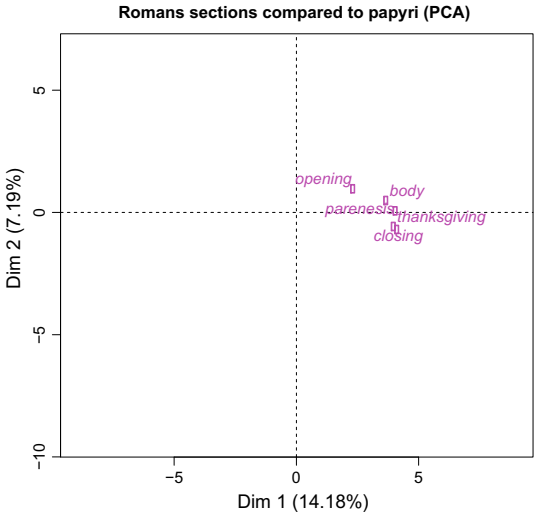

Fig. 12 Principal component analysis of papyri and ostraca texts with distribution of Romans sections overlaid

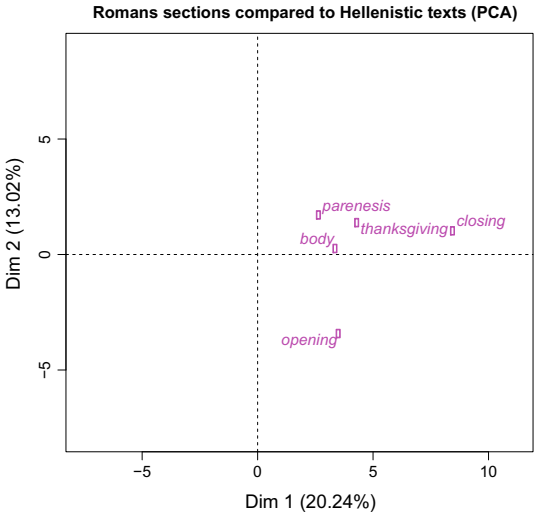

Fig. 13 Principal component analysis of Hellenistic texts with distribution of Romans sections overlaid

Table 9 Coordinates of Romans sections according to New Testament dimensions

	Dimension 1	Dimension 2
Opening	9.18	−3.06
Thanksgiving	1.99	2.56
Body	−0.57	0.05
Parenthesis	0.42	0.87
Closing	4.68	0.34

Table 10 Coordinates of Romans sections according to papyri dimensions

	Dimension 1	Dimension 2
Opening	2.37	1
Thanksgiving	4.03	−0.55
Body	3.72	0.52
Parenthesis	4.1	0.09
Closing	4.16	−0.67

Table 11 Coordinates of Romans sections according to Hellenistic texts dimensions

	Dimension 1	Dimension 2
Closing	8.51	1.05
Body	3.41	0.29
Thanksgiving	4.35	1.41
Parenthesis	2.7	1.74
Opening	3.56	−3.39

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