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A Stylometric Analysis of Mormon Scripture and Related Texts

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SUMMARY

This paper proposes a multivariate approach to measuring the richness of vocabulary of a literary text as a tool for problems of attribution of authorship. This approach is then applied to the corpus of Mormon scripture. The historical foundation of the Mormon Church, in particular the church's dependence on the authenticity of the story of Joseph Smith and the genesis of the *Book of Mormon*, has become increasingly subjected to the stress of open inquiry. This paper contributes to this questioning of the origins of the Mormon faith by assessing the stylometric evidence for or against multiple authorship of the *Book of Mormon* itself.

Keywords: *BOOK OF MORMON*; CLUSTER ANALYSIS; *HAPAX DISLEGOMENA*; *HAPAX LEGOMENA*; PRINCIPAL COMPONENTS ANALYSIS; STYLOMETRY

1. INTRODUCTION

A comprehensive review of the statistical analysis of literary style has been provided by Holmes (1985). In that paper it was apparent that a particularly effective measure for discrimination between writers was the richness of vocabulary of a text. To obtain suitable quantitative indicators of richness of vocabulary, we should not only take into account the text length itself (N words) but also the number of different words in the text (V) and the structure of the vocabulary frequency distribution, i.e. how many words are used once only in the text (V_1), how many words are used twice (V_2), etc. The choice of the number of different words as a counting unit allows the stylometric analyst the freedom of working on the raw data and of operating a lemmatization, in which repetitions and inflections of a unique word are treated as one, according to norms which he can define himself. This choice may run the risk of treating the individual written or printed word as unduly sacrosanct, yet, to date, no stylometrist has managed to establish a methodology which is better able to capture the style of a text than that based on lexical items.

With the power of computers readily available, the selection of multiple criteria must now be favoured to tackle problems of attribution of authorship. This paper puts forward a case for a multivariate approach to measuring richness of vocabulary, employing variables each of which reflects a different aspect of an author's vocabulary distribution. It then applies these techniques to a body of writings which are directly relevant to establishing the authenticity of the *Book of Mormon*. The writings to be analysed include the *Book of Mormon* itself, the personal writings of Joseph Smith, its mediator, the 1611 *King James Authorised Holy Bible*, the *Doctrine and*

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Covenants of the Church of Jesus Christ of Latter-day Saints (a collection of divine revelations mostly received through Joseph Smith) and the *Book of Abraham* from the *Pearl of Great Price*, the latter purporting to be a translation by Joseph Smith of the writings of the biblical patriarch.

2. RICHNESS OF VOCABULARY—MULTIVARIATE APPROACH

2.1. *Hapax Legomena*

In vocabulary frequency distributions, the largest group is of words which occur once in the text, V_1 (*hapax legomena*), and it is natural that one measure at least of richness of vocabulary should involve this particular count.

Morton (1986) comments:

> 'The once-occurring words convey many of the elements thought to show excellence in writing, the range of a writer's interests, the precision of his observation, the imaginative power of his comparisons; they demonstrate his command of rhythm and of alternations. The potential of once-occurring words as an indicator of authorship seems obvious, as a group they display so much that appears characteristic of the individual and the choices which must be made in composition.'

Morton defines a once-occurring word as 'a form not repeated in the sample' and says that we ought not to concern ourselves with supplementing form by meaning (e.g. the word 'saw' could be either a noun or a verb), since the proportion of such occurrences is much less than 1% of the total according to detailed examinations of samples of both Greek and English. He does not, therefore, separate homographs.

Morton's theme in his 1986 paper is that it is the position of these once-occurring words in the sentence which enables one writer to be distinguished from another. *Hapax legomena* occur relatively infrequently as first words of sentences but at an enhanced rate as last words, and Morton goes on to study such patterns in the epistles of the Pauline corpus. The problem with this approach is that it involves punctuation in the defining of a sentence, a matter of lesser difficulty, perhaps, in Greek prose, but somewhat dubious in cases like mediaeval texts or in Shakespeare's works where the punctuation often represents editorial intervention. Here Morton abandons punctuation and studies the positions of *hapax legomena* in relation to particularly frequent words such as 'a, and, in', etc. He claims that Shakespeare is entirely consistent in his habit of placing once-occurring words before and after such marker words.

Smith (1987) conducts a detailed investigation into the validity of Morton's approach, examining both its statistical implications and the range and quality of his evidence. Smith concludes, correctly, that much of Morton's work is not sound from a statistical point of view, many calculations having been performed without regard for the existence of an underlying theory. There is no evidence, therefore, that once-occurring words in prescribed positions within sentences can discriminate between authors. This is not to say that *hapax legomena* are of little use in the attribution of authorship. Smith points out that Morton's tests depend only on numbers of once-occurring words in prescribed locations and not directly on their total in a text. The difficulty is simply that Morton has provided no real evidence to support his premise that authors are distinctive in how they place their rare words in sentences.

The behaviour of *hapax legomena* has been investigated by Brainerd (1988). A

hypothesis of a fixed maximum available vocabulary would imply that the expected number of *hapax legomena* would increase, assume a maximum and then decrease to 0 as $N \to \infty$. However, by drawing different-sized samples from the same work, Brainerd shows that the relation between V_1 and V for a text of 200000 words is very nearly a straight line with positive slope, and for the 2-million-word Kierkegaard corpus $V_1/V = 0.4359$ whereas for a representative sample of 103 million words of American English $V_1/V = 0.4472$. Brainerd suggests that the vocabulary available to an author may not be fixed but may grow linearly with time. He also finds that, in the Kierkegaard corpus, for works with nearly equal Ns the Vs and V_1s can be quite different, indicating differing use of vocabulary across the works.

It is clear, then, that if we are to use *hapax legomena* in some form as one variable in a multivariate approach to richness of vocabulary our variable should contain both N and V. A function which does just this is suggested by Honoré (1979) and is defined by

$$R = \frac{100 \log N}{1 - V_1/V}.$$

It directly tests the propensity of an author to choose between the alternatives of employing a word used previously or employing a new word. In the extreme case when each word type in a text is used once only, $V_1 = V$, and R becomes infinite. When comparing texts, therefore, the higher the R-value is, the richer the vocabulary in the sense that a greater number of words appear infrequently. Honoré applied this formula to texts from 39 legal authors, writing in Latin, contained in Justinian's *Digest* (533 AD) and found that it appeared stable above text sizes of $N = 1300$ words. From an additional study of five works of Cicero, Honoré found that the first two works (dated to 70–66 BC) gave results in the 1100s whereas the last three (dated to 45–43 BC) gave results in the 1300s. If Cicero's vocabulary increased in richness over the intervening 20-year period, which is plausible, then the R-function may successfully measure change over time in richness of vocabulary and be helpful when problems of dating are at issue.

It is proposed to use the function R as one variable in the multivariate measure of richness of vocabulary advocated in this paper.

2.2. *Hapax Dislegomena*

The behaviour of words used only twice in a given text (*hapax dislegomena*) has been investigated by Sichel (1986) with a mathematical model which will be discussed later in this section. Sichel found that the proportion of *hapax dislegomena* increased very rapidly with increasing N then stayed constant for a very long interval of token counts before dropping very gently towards 0 as $N \to \infty$. His model showed stability of the proportion of *hapax dislegomena* between $1000 < N < 400000$ and tests on real data corroborated this theoretical result, i.e. for a particular author this proportion, as observed over a wide range of token counts, is virtually constant. As illustration, consider the following example taken from Sichel (1986):

	N	V_2/V
Random samples of nouns drawn from	2000	0.1872
Macaulay's *Essay on Bacon*, the samples being	4049	0.1767
of different sizes	6004	0.1763
	8045	0.1792.

Sichel postulates that, although the proportion of *hapax legomena* is decreasing with increasing N, the near invariance of the proportion of *hapax dislegomena* may be due to equilibrium being reached. With increasing N, as many words could be lost from this category to become thrice-occurring words as, proportionately, are received from the once-occurring word category.

The interesting discovery of the near constancy of the proportion of *hapax dislegomena* for a writer, whatever the number of tokens counted, suggests that the function V_2/V would be a very appropriate variable to use in a multivariate approach to richness of vocabulary.

2.3. *Yule's Characteristic K*

Yule (1944) devised a well-known 'characteristic K', a measure of richness of vocabulary based on the assumption that the occurrence of a given word is based on chance and can be regarded as a Poisson distribution. K is defined by

$$K = 10^4(\Sigma i^2 V_i - N)/N^2 \qquad (i = 1, 2 \ldots).$$

Tallentire (1972) found that a wide range of K-values is usually obtained, even when sampling works from the same authors, and suggests that K is not well suited to attribution problems. He recommends that all words should be used when calculating K, not just, for example, common nouns, and that K values should not be used in isolation in studies of authorship since the degree of repetition revealed in vocabulary is probably not an unconscious aspect of style.

As a measure of repetitiveness K is stable and relatively unaffected by text size. Sichel (1986) proves that, under the Poisson assumption, K is constant with respect to N, and Weitzman (1988) also comments on this favourable property of K. It is therefore proposed to use K as a variable in the multivariate model.

2.4. *Sichel Distribution*

The Sichel (1975) distribution is a theoretical model for vocabulary distributions (V_i). He obtained an excellent fit of his distribution to numerous word occurrence data from various texts and we may note that Bartholomew (1988) has remarked:

> 'it may be fruitful to explore their [Sichel and related distributions] applicability to literary texts'.

If $\phi(r|N)$ is the probability that any word type turns up exactly r times in a text of length N, then the Sichel model to represent observed word frequency distributions is given by

$$\phi(r|N) = \frac{(2\alpha/\pi)^{1/2}\exp\alpha}{\exp[\alpha\{1-(1-\theta)^{1/2}\}]-1}\,\frac{(\frac{1}{2}\alpha\theta)^r}{r!}\,K_{r-1/2}(\alpha) \qquad (r = 1, 2, \ldots, \infty)$$

where $\alpha > 0$, $0 < \theta < 1$ and $K_{r-1/2}(\alpha)$ is the modified Bessel function of the second kind of order $r - \frac{1}{2}$ and argument α. Sichel obtained estimates of parameters α and θ by using V_1/V and N/V but the method is somewhat laborious and Sichel admits: 'A method far better . . . is to vary estimates α and θ until the total χ^2 is minimized, or nearly so'. This writer has produced such a procedure, written as a Pascal computer program, which enables the Sichel distribution to be fitted to any vocabulary distribution and which computes best fitting estimates of parameters α and θ. It is also

possible to compute standardized values of α and θ, these being the estimates obtained if the length of text under analysis was, say, exactly 10000 words. This possibility arises as a consequence of some interesting invariance properties obtained during the formulation of the Sichel model. It is necessary to derive these '10000-equivalent' estimates of α and θ since the parameters are very dependent on text length N.

The invariance properties concern two parameters b and c which Sichel defines as

$$b = \alpha(1-\theta)^{1/2}$$

and

$$c = \theta/(1-\theta)N.$$

Sichel shows that, whatever the value of N, the combination of parameters α and θ in these equations will always lead to the constant parameters b and c. Using the estimates of α and θ from the data under investigation, we may compute b and c, then, with $N = 10000$, we use these equations again with the fixed b and c to obtain the 10000-equivalent estimates of α and θ.

We now come to the crucial question of the use and interpretation of parameters α and θ in the Sichel model. This has been investigated by Pollatschek and Radday (1981, 1985) who noted that Sichel had made no attempt to do this despite the superb fit of his distribution to numerous word occurrence data from various texts. They plotted various theoretical distributions from the Sichel model for different sets of values of α and θ and noted that the slope of the tail of the distribution was defined by θ alone whereas that of the head was defined by α alone. Pollatschek and Radday conclude that α and θ together describe the whole vocabulary distribution in full, and the Sichel distribution hence becomes a powerful tool in measuring richness of vocabulary. The values of α and θ could act as a discriminant between two writers. The authors then experiment to this effect using several biblical books and the 10000-equivalent values of α and θ previously discussed. They found that α and θ are not negatively correlated; in fact any of the four (high, low) possibilities may characterize a text.

The vocabulary of the *Book of Genesis* was examined with the text separated into three categories: the words of the narrator (N), human direct speech (H) and divine direct speech (D). On an α–θ plot involving several textual samples from all three categories, Pollatschek and Radday (1985) found that the N-, H- and D-samples were consistent within themselves yet the three categories were unmistakably separated and exhibited three entirely different ways of behaviour in their vocabulary properties. The authors concluded that this was an almost inexplicable literary feat which would have been difficult to achieve by one writer, let alone a documentary school of several writers who some claim have had a share in composing *Genesis*. Other applications in the original Hebrew include the *Book of Lamentations* and the *Book of Zechariah*.

2.5. *Conclusion*

We now have five variables, each of which measures the richness of vocabulary of a writer in some sense, yet are stable with regard to text length—a most important attribute. These five variables, Honoré's R, V_2/V, Yule's K and 10000-equivalent values of α and θ in the Sichel model, collectively cover the whole structure of the writer's vocabulary frequency distribution.

This paper therefore proposes a multivariate approach to measuring richness of vocabulary which employs all five of these variables together in the statistical analysis of a literary text. It is now appropriate to consider the proposed area of application.

3. *BOOK OF MORMON*

The *Book of Mormon* claims to reflect the experiences of a family of Jews who escaped from Jerusalem just before its destruction by the Babylonians in 597 BC. The family is reported to have constructed a ship somewhere in the Gulf of Suez or on the Persian Gulf and to have sailed from there to America, thus arriving on that continent 2000 years before Columbus. This emigré Jewish Community is further reported to have written in America the books which compose the *Book of Mormon* and to have engraved them on golden plates. These plates are said to have been found by one Joseph Smith who took possession of them in 1827 and translated them with the aid of a seer stone and of stones known as the Urim and Thummim. Urim and Thummim are referred to in several places in the *Old Testament*. They seem to have been a kind of sacred dice, the throwing of which was believed to furnish a quick answer from God when direction was urgently needed, as in 1 *Samuel*, chapter 28, 1–6.

Although part of the *Book of Mormon* purports to have been written in America by several authors in the sixth century BC, it is full of allusions to and quotations from the *New Testament*, which was not written until the first century AD. For example, in the first book of the *Book of Mormon* (1 *Nephi*, chapter 10, 9) the writer says, speaking of John the Baptist: 'He should baptize in Bethabara beyond Jordan'. The name Bethabara only appears in one place in the *Bible*, in *St John's Gospel*, chapter 1, 28, where it is, in fact, a mistake. The correct name of the place in question is Betharaba, which suggests that the author of the book of Nephi had drawn on St John's gospel and had even taken over this mistaken reading. Fawn Brodie, whose book *No Man Knows my History* is considered by many Mormon historians to be the definitive biographical study of Joseph Smith, also refers to this error (Brodie (1971), p. 70). The *Book of Mormon* quotes considerable sections of the *New Testament* word for word, yet asks us to believe that Nephi and his relations wrote their account in America 600 years before Christ was born. For authoritative histories of the origins of the Mormon faith and the genesis of the *Book of Mormon*, the reader is referred to Bushman (1984) and Shipps (1985).

A statistical analysis of the *Book of Mormon* in an effort to test competing authorship claims has been carried out by Taves (1984). Taves selects three samples of text from the *Book of Mormon* chosen, in turn, from *Nephi*, *Mosiah* and *Alma*, but takes no account of editing or abridging or indeed of who is purportedly speaking within these samples. He assumes that these books are written completely by the authors specifically named, despite the fact that in the *Book of Mormon* prophets frequently quote other prophets. Taves compares these samples with the *Book of Abraham*, a work 'translated' by Joseph Smith from one of several papyrus scrolls acquired in Kirtland, Ohio, in 1835 and published in 1842, more than a decade after publication of the *Book of Mormon*.

He first examines the occurrences of frequent words in preferred positions in sentences, a risky undertaking since all punctuation was inserted by typesetters when the manuscript itself finally went to press (see Brodie (1971), p. 54). Taves found that *Nephi* differed significantly from the other three texts in the rate of appearance of

'and' as the first word of a sentence, but then conceded that this was entirely due to the frequent use of the phrase 'And it came to pass'. Removing this phrase from his *Nephi* sample, he found that no significant difference over this feature then remained. Taves found another distinguishing criterion in the appearance of 'the' as the penultimate word of a sentence, this placement occurring significantly more frequently in *Nephi*. He then once more explains away any differences, arguing that this result is due to Nephi's habit of ending sentences with 'the wilderness' and that removal of these occurrences leaves no significant difference between the four texts in this respect.

Taves (1984) then turns his attention to collocations and applies 25 tests, very few of which contain enough occurrences for all four texts to be compared. The only significant discrepancy he found was for the group 'and' followed by 'the', in the use of which Alma differed from the other three.

The next battery of tests is directed at proportionate pairs; in fact his whole work is in the mould of Morton (1978). Only three categories yielded sufficient instances to test and none of these showed any difference between the four texts. Taves's final tests concern the number of times *hapax legomena* occur immediately before and after certain marker words, a test that carries word placement to the extreme and is surely of little stylometric import. Again, no significant differences were found. Taves concludes that, on the basis of all his tests, the hypothesis that the four texts come from one hand is not disproven.

The most impressive statistical analysis carried out on the *Book of Mormon* is that undertaken by Larsen *et al.* (1980), academics at Brigham Young University, the Mormon University in Utah. Their aim was to test the assumption that the *Book of Mormon* was written by a single author (Joseph Smith or another person) against the alternative hypothesis of multiple authorship. These researchers realized that a conclusion in favour of single authorship would not necessarily invalidate believers' claims. Smith, even under divine direction, might have paraphrased the text into his own words or, alternatively, he could have received the translation word for word in a uniform literary mode with all stylistic differences between authors obliterated. This latter idea, however, suggests the thought that the plates themselves were incidental to the genesis of the work and that Smith was simply dictating while staring into his seer stone or the Urim and Thummim. For a control Larsen *et al.* (1980) also analysed the writing of several authors who were contemporaries of Joseph Smith.

The Brigham Young team made two initial assumptions: firstly that each of the major engravers of the plates and those sources they quoted were distinct individuals, and secondly that the writers of each verse in the *Book of Mormon* could be identified according to the information given in the text. There are four major engravers of the plates. Mormon engraved 174610 words or 65.1% of the book, Nephi 54688 words (20.4%), Moroni 26270 words (9.8%) and Jacob 9103 words (3.4%). Larsen and his collaborators found very little ambiguity about who wrote which sections, but stressed that careful scrutiny of each verse was required since authorship or source shifted about 2000 times in the text. Some of these changes were extremely rapid, taking place within fewer than 10 words.

The example in Table 1 from *Alma* 8 illustrates how quickly these changes occur.

In their study, Larsen *et al.* (1980) used multivariate analysis of variance (MANOVA), cluster analysis and discriminant analysis. The writings of 24 candidate authors in the *Book of Mormon* and of Joseph Smith and his contemporaries were divided into blocks of text containing approximately 1000 words each. The analyses

TABLE 1

Source	*Segment*
Mormon	19. And as he entered the city he was an hungered, and he said to a man:
Alma	Will you give to an humble servant of God something to eat?
Mormon	20. And the man said unto him:
Amulek	I am a Nephite, and I know that thou art a holy prophet of God, for thou art the man whom an angle said in a vision:
Angel	Thou shalt receive.

were conducted on the frequencies of appearance within each block of 38 common non-contextual words and of 42 uncommon words. Larsen *et al.* conclude that their results 'all strongly support multiple authorship of the *Book of Mormon*'. They stress that one of the implications of the result is that it was impossible that Joseph Smith, or indeed anyone else, could have fabricated a work with 24 distinct authorship styles, and kept track of at least 38 word frequencies to vary them from author to author. The translation must therefore have been given to Joseph verbatim. The authors of the *Book of Mormon*, the study concludes, also did not resemble any of the 19th-century authors. The MANOVA analysis using the 42 uncommon non-contextual words is stated to have shown even more highly significant differences between the 24 *Book of Mormon* authors than those involving the 38 common words.

Although in many ways this is an impressive study, it leaves the reader with a feeling of unease in that a minimum of statistical information is provided whereas the outcome supports orthodox Mormon belief completely. The whole case made in this piece of research rests on the assumption that the frequency of occurrence of non-contextual function words is a stylistic discriminator. The paper claims that authors differ in their rates of usage of these words.

A more rigorous investigation involving complete vocabulary distributions, not just occurrences of certain words, is needed here.

It is also hardly reassuring to read the bald statement made by the authors concerning Shakespeare. The paper states (Larsen *et al.* (1980), p. 243) that 'the unity of Shakespeare's plays has also been questioned, but when these plays were subjected to wordprint analyses, no significant variations in wordprint were found within the given plays'. This is a very superficial view for which Larsen and his collaborators provide no statistical support. The work of Merriam (1982), for example, has since indicated many significant discrepancies within Shakespeare's oeuvre. One wonders, moreover, what was the scholarly basis of the claim that 'And it came to pass' was undoubtedly represented by one word in reformed Egyptian, the language in which the plates were supposedly engraved.

The study found no resemblance between the authors of the *Book of Mormon* and the 19th-century authors sampled, but the case rests on usage of words such as 'unto, behold, yea, forth, verily, exceeding, thereof, lest, nay, whereby and thereby' which would all naturally be prominent in an archaic biblical-type style, but could hardly be expected to occur with this frequency elsewhere, even in the early 19th century. This

lack of resemblance, therefore, may be real but spurious. The fact that 'came' and 'pass' are adjacent in Larsen's list of frequently occurring words, each occurring virtually the same number of times in the text, bears out the biblical influence.

When attempting such an analysis it is important to select criteria which are valid and unchallengeable. If there is doubt about Larsen's tests owing to the nature of the *Book of Mormon's* style then other statistical tests should be used, tests which are not totally dependent on the choice of vocabulary. This study now proposes to apply to the *Book of Mormon* the multivariate vocabulary richness approach detailed in Section 2.

4. SAMPLING AND TEXTUAL PREPARATION

4.1. *Book of Mormon*

This study concerning the authorship of the *Book of Mormon* would have been difficult, if not impossible, to carry out had it not been for the loan of a copy on computer tape of the scripture database of the Humanities Research Center at Brigham Young University. On this tape were text files of the *Book of Mormon*, the *King James Bible* and scriptures of the Latter-day Saints such as the *Doctrine and Covenants* and *Pearl of Great Price*.

The tape was accessed via the Bristol Polytechnic Prime computer system and after teething problems with the removal of control characters inserted by the system at Brigham Young University the database was eventually ready for the task of editing and extracting sections of text.

The editing of the *Book of Mormon* text file was extremely time consuming. The identification of the source of each verse or portion of a verse needed great care since there are approximately 2000 shifts of authorship or source in the text of the *Book of Mormon* (Larsen *et al.*, 1980). The absence of quotation marks meant that sections of text had to be followed very closely if one was to be certain not to miss a change in narrator, and summaries placed by the publisher at the beginning of each chapter had also to be edited out.

Recent work by Tanner and Tanner (1980), p. 128, has shown that at least 3913 changes have been made in the text of the *Book of Mormon* since it was first published in 1830. Most of the changes relate to the correction of grammatical and spelling errors and were made by Joseph Smith himself in the second edition in 1837. The first edition was not even divided into chapters and verses. Joseph Smith had difficulty with the verb 'to be', and both Tanner and Tanner (1980), pages 130–131, and Ropp (1987), p. 44, give examples of extracts from the first edition of the *Book of Mormon* which are grammatically incorrect in their usage of this verb. These were corrected in later editions. As the Tanners point out (p. 130): 'the first edition of the *Book of Mormon* plainly shows that it was written by a man who did not have a great deal of education, although we must admit that the writer had ability and imagination'. They argue that, although these changes should not be overemphasized, they are important when considering Smith's claims that the *Book of Mormon* was 'the most correct of any book on earth' (Smith (1951), volume 4, p. 461).

The aim of the present writer's editing process was to produce samples of text, each approximately 10000 words in length, of 'pure' writing by prophets. For example, the *First and Second Books of Nephi* not only contained Nephi's words but also those of

Lehi and Jacob, among others. These sections attributed to Jacob were edited out of the *Books of Nephi* and placed in separate files to which were added more of Jacob's and Lehi's words found, for example, in the *Book of Jacob*.

Two samples of Alma's words were taken from the *Book of Alma* and five samples of Mormon's words were taken from the *Books of Mosiah, Alma and Helaman*. Finally, two samples of Moroni's words were similarly extracted from the *Books of Moroni, Mormon and Ether*. The 14 samples of pure prophet writing ultimately extracted in this way by editing the textual database of the *Book of Mormon* may be summarized as follows:

(a) Nephi 1—9569-word sample of Nephi's words from the *First Book of Nephi*;
(b) Nephi 2—7788-word sample of Nephi's words from the *First and Second Books of Nephi*;
(c) Nephi 3—8900-word sample of Nephi's words from the *Second Book of Nephi*;
(d) Jacob—8112-word sample of Jacob's words from the *Books of Nephi and Jacob*;
(e) Lehi—4606-word sample of Lehi's words from the *Books of Nephi*;
(f) Moroni 1—10164-word sample of Moroni's words from the *Books of Moroni and Ether*;
(g) Moroni 2—9483-word sample of Moroni's words from the *Books of Ether and Mormon*;
(h) Mormon 1—9999-word sample of Mormon's words from the *Book of Mosiah*;
(i) Mormon 2—9988-word sample of Mormon's words from the *Book of Alma*;
(j) Mormon 3—10029-word sample of Mormon's words from the *Book of Helman*;
(k) Mormon 4—9999-word sample of Mormon's words from the *Book of Alma*;
(l) Mormon 5—10060-word sample of Mormon's words from the *Book of Alma*;
(m) Alma 1—10003-word sample of Alma's words from the *Book of Alma*;
(n) Alma 2—10000-word sample of Alma's words from the *Book of Alma*.

There was a very small overlap (a few hundred words) between the two Moroni samples and also between the two Alma samples; otherwise all samples were independent of each other. The 14 pure word samples representing utterances of individual prophets were all stored in separate computer files ready for the analysis which is described fully in Section 5.

4.2. *Joseph Smith's Personal Writings*

As a control we need to compare the style of writing in the *Book of Mormon* with that of Joseph Smith himself. Fortunately the means of doing this are to hand in Jesse (1984). In his preface, Jesse laments that our understanding of Joseph Smith as a person is obscured by the fact that he depended greatly on others to write for him. Jesse lists the difficulties concerning exactly how far Smith's sizable collection of papers reflects his own thoughts and personality. He refers to: '. . . the lack of personal writing, the wide use of clerks taking dictation or even being assigned to write for him, and the editorial reworking of reports of what he did and said'.

Jesse suggests that the greatest distortion occurs at points where other personalities have intruded between Joseph Smith and the reader; in the preservation of his speeches, for example, shorthand skills were not sufficiently developed among his clerks to allow verbatim reports of what he said. Nevertheless, with impressive scholarship, Jesse has attempted to separate Joseph Smith's own writings from what others wrote for him and to publish only what was written in his own hand or specifically dictated to a scribe. Jesse (1984) contends (p. 19) that these personal writings remove the editorial props and present Smith's true character, giving an accurate reflection of his thoughts and personality.

The documents presented by Jesse can be listed under two general headings:

(a) diaries and histories containing diary material covering the years between 1832 and 1842;
(b) letters and documents, many in Smith's own handwriting, written between 1828 and 1844.

As a control only those letters written by Joseph Smith himself, or preserved in the handwriting of clerks who state specifically that Smith is dictating, were extracted. To match the time span as far as possible to the publishing of the *Book of Mormon* itself, only those letters, diaries and histories written between 1828 and December 1833 were selected.

All this material was typed into a computer file and the resultant text corpus was then divided into three samples of approximately equal size:

(a) Joseph Smith 1, 6032 words;
(b) Joseph Smith 2, 5715 words;
(c) Joseph Smith 3, 6422 words.

These samples, like the earlier samples, were then stored in separate computer files ready for analysis.

4.3. *Doctrine and Covenants*

The *Doctrine and Covenants* is one of the standard works of the Mormon Church and is a collection of divine revelations and declarations given for the establishment of the Church of Jesus Christ of Latter-day Saints and its regulation. Most of these revelations were received through Joseph Smith. *Doctrine and Covenants* is therefore not a translation of an ancient document but is of relatively modern origin and claims to make heard 'the tender but firm voice of the Lord Jesus Christ, speaking anew . . . preparatory to his second coming'.

The revelations were supposedly received when Joseph Smith and his associates prayed for divine guidance. They are not reports of experiences written in the first person; the speaker instead appears, as it were, to stand outside Smith and to talk to him with both force and style. The words have a scriptural flavour but are not direct quotation. Bushman (1984), p. 94, contends that, although Smith read the *Bible* less than his brothers and, from 1820, stayed away from preachers, the words could not have been imitated even if he had been exposed to sermons. Taves (1984), p. 45, notes, however, how David Whitmer (one of the three witnesses) considered that the Church began to fall into error as soon as the manuscript for the *Book of Mormon* had been completed, at which point Smith abandoned the seer stone and simply

spoke subsequent revelations, as God's mouthpiece. Taves quotes from p. 36 of Whitmer's (1887) *Address to All Believers in Christ*:

> 'Brother Joseph would listen to the persuasions of man, and inquire of the Lord concerning different things, and the revelations would come just as they desired and thought in their hearts'.

In 1833 the Mormon Church published these revelations in a book entitled *Book of Commandments*. In 1835 the revelations were printed again and the name of the book was changed to *Doctrine and Covenants*. An impressive comparison of the two documents has been made by Tanner and Tanner (1980), pages 38–66, revealing the drastic changes made from the one to the other, some verses being rewritten, some omitted and some added to support doctrines which Joseph Smith had begun teaching. The Tanners note (p. 42) how David Whitmer attested to the accuracy of the *Book of Commandments* yet objected to the changes made for the new book.

One of the most significant changes concerns the fourth chapter of the *Book of Commandments* where Joseph is told in a revelation that he would have no other gift than the ability to translate the gold plates. The very existence, therefore, of the *Book of Commandments* was a contradiction. The basic meaning of this revelation was subsequently changed in *Doctrine and Covenants* to make it appear that God would grant Joseph other gifts besides that of translating the *Book of Mormon*.

Doctrine and Covenants purports to be the revelations given directly from God to Joseph Smith. These revelations ought to be completely free from alteration. Many Mormons (see Tanner and Tanner (1980), p. 64) try to justify the changes actually made by saying that God has a right to change his mind, although it is difficult to conceive that God could reverse his position on matters of doctrine. To admit that the changes were made by Joseph Smith would be to admit that God is not the author. Ropp (1987), p. 71, argues that 'we must conclude that the revelations on which the essential doctrines are based originated not with God, but with Joseph Smith'.

It is important in this study, therefore, to compare the style of Joseph Smith's prophetic voice with his personal writings and the *Book of Mormon* itself. Several of the earlier sections in *Doctrine and Covenants* involve matters relating to the translation and publication of the *Book of Mormon*, so sampling was aimed at these sections in particular. Accordingly, three independent samples, of 9983, 9982 and 9974 words, were selected from sections 1–51 of *Doctrine and Covenants* and stored in separate computer files.

4.4. *King James Bible*

Mark Twain, reflecting on the *Book of Mormon* in chapter 16 of *Roughing It* expressed the opinion that 'If Joseph Smith had left "and it came to pass" out, his Bible would have been only a pamphlet' (Twain, 1972).

Certainly there are many similarities between the *Book of Mormon* and the 1611 *King James Authorised Holy Bible*, a point acknowledged by the Mormon Church which in a footnote to their 1981 edition of the *Book of Mormon* acknowledges that there are 433 verses of *Isaiah* quoted in the book, 200 of which have the same wording as in the *King James Bible*. Examples are *Isaiah*, chapters 2–14, which correspond with 2 *Nephi*, chapters 12–24, and *Isaiah*, chapters 48–49, which correspond with 1 *Nephi*, chapters 20–21.

Brodie (1971), p. 58, bluntly claims that, when writing the early part of the *Book of Mormon*, Joseph Smith's literary reservoir 'frequently ran dry' at which point he simply arranged for his Nephite prophets to quote from the *Bible*. Brodie contends that Joseph did make minor changes in these biblical extracts so that his readers would not be concerned about how an ancient American prophet could be using the exact text of the *King James Bible*.

Ropp (1971), p. 50, asserts that the *Book of Mormon* is written in imitation of the style of the King James version. Tanner and Tanner (1980), p. 115, are also in no doubt that the first books of the *Bible* furnished a large amount of source material for the writing of the *Book of Mormon*. The Tanners note the claim of the Mormon leaders that the Nephites possessed the *Old Testament* books which were written before they left Jerusalem around 600 BC, but also point out that the *Book of Mormon* borrows from books written after 600 BC. The most serious discrepancy concerns quotations from the *Book of Malachi*. Verses written by Malachi about 400 BC (*Malachi*, chapter 4) reappear in some verses supposedly written by Nephi sometime between 588 and 545 BC (1 *Nephi*, chapter 22, 15, and 2 *Nephi*, chapters 25–26).

The Nephites were not supposed to have had access to the books of the *New Testament*, yet Tanner and Tanner (1980), pages 117–121, list an impressive number of parallels between verses in it and the *Book of Mormon*. They find over 100 quotations from the *New Testament* in the first two books of Nephi alone, books supposedly written between 600 and 545 BC.

Another serious discrepancy concerns Christ's appearance to the Nephites immediately after his crucifixion when he tells them that he is going to quote the words of Moses. The words he should have quoted are in *Deuteronomy*, chapter 18, 15–19, yet Jesus quotes from Peter's paraphrase of Moses's words found in *Acts*, chapter 3, 22–26.

Mormon's account of Christ's appearance and speech (3 *Nephi*, chapter 20, 23–36) therefore follows Peter's paraphrase rather than the actual words of Moses. The *Book of Mormon* quotes *Acts* at this point, yet the *Acts* was not written until 20 or 30 years after the time of the purported writing of this section of the *Book of Mormon* (Tanner and Tanner (1980), p. 123).

Tanner and Tanner (1980) conclude (p. 124):

> 'Mormon writers have tried to explain why so much of the *New Testament* is found in the *Book of Mormon*, but we feel that their explanations are only wishful thinking. The only reasonable explanation is that the author of the *Book of Mormon* had the King James Version of the *Bible*. And since this version did not appear until A.D. 1611, the *Book of Mormon* could not have been written prior to that time. The *Book of Mormon*, therefore, is a modern composition and not a record of ancient religious history.'

As a control it is important, therefore, to include text from the *King James Bible* in this investigation into the authorship of the *Book of Mormon*. It was decided to choose the *Book of Isaiah*, since this particular *Old Testament* book figures largely in previous discussions. Many present-day biblical scholars espouse the theory that there were at least two authors of *Isaiah*, the principal divisions being chapters 1–39 and 40–66. Larsen *et al.* (1980) subjected the English text of *Isaiah* to the word frequency tests described earlier and were unable to detect any statistical difference between these divisions.

The text of the *Book of Isaiah* was divided into three samples as follows:

(a) chapters 1–25, 5, 12776 words,
(b) chapters 44, 19–66, 12090 words and
(c) chapters 25, 6–44, 18, 12164 words,

and these were stored in separate computer files ready for analysis.

4.5. *Book of Abraham*

The authorship of the *Book of Abraham* has caused much controversy among Mormon historians. It was noted before that Taves (1984) uses the text of the *Book of Abraham* as a control measure of Joseph Smith's personal writings, a procedure which, in a way, prejudges his results.

The *Book of Abraham* was claimed to have been written on papyrus by the biblical patriarch about 4000 years ago. According to Mormon history, this same papyrus fell into Joseph Smith's hands in 1835. He translated and published it under the title *The Book of Abraham* in 1842. It was accepted by the Mormon Church as scripture and is now published as part of the *Pearl of Great Price*, one of the standard works of the Church. If the papyrus was written by Abraham then it would be of incalculable historical value. If Joseph Smith is guilty of misrepresentation, however, then serious doubt would be cast on the *Book of Mormon* itself and on other writings which he claimed as scripture. A study of the stylistic characteristics of the *Book of Abraham* is therefore of pivotal importance to the present study.

After purchasing papyri and some mummies from a certain Michael Chandler in Kirtland, Ohio, in 1838, Joseph Smith declared:

> 'I commenced the translation of some of the characters or hieroglyphics, and much to our joy found that one of the rolls contained the writings of Abraham, another the writing of Joseph of Egypt, etc . . .' (Smith (1951), volume 2, p. 236).

At that time only a few scholars were familiar with the ancient Egyptian language (see Doblhofer (1973)) and there was, presumably, little chance of Joseph Smith's work coming into direct conflict with the science of Egyptology during his lifetime. With the murder of Joseph Smith in 1844 and the Mormon emigration to the west in the late 1840s, the Mormon Church lost control of the collection of papyri (Tanner and Tanner (1980), p. 332).

In November 1967, a collection of papyri was presented to the Mormon Church by the Metropolitan Museum of Art, New York, among which was a fragment identified as the original from which Joseph Smith had copied the drawing which he called 'Facsimile No. 1' and published with the *Book of Abraham*.

The identification of a particular fragment of papyrus as the original from which Joseph Smith translated the *Book of Abraham* has been made possible by comparison with *Joseph Smith's Egyptian Alphabet and Grammar*, a handwritten document in which Joseph Smith first wrote down his translation. Both Tanner and Tanner (1980), p. 341, and Ropp (1987), p. 82, reproduce a portion of this document and it is immediately noticeable that Joseph Smith renders each Egyptian character by a large number of words, 1125 words corresponding to just 46 characters. Tanner and Tanner (1980) note (p. 343) that if Joseph Smith continued to translate each Egyptian character by the same number of English words, then the 5470-word text of the *Book*

of Abraham would probably be contained in just this one fragment of papyrus. A detailed character-by-character analysis of the translation is conducted by Ropp (1987), pages 81–86.

This important papyrus fragment was studied and translated by prominent Egyptologists in the late 1960s and pronounced to be part of the Egyptian *Book of Breathings*, a mortuary text which was usually placed with a corpse for protection and guidance in the after-life, and which is not attested until a few centuries before the time of Christ (Tanner and Tanner (1980), p. 345).

Another good case against the authenticity of the *Book of Abraham* can be made on the basis of the facsimiles printed in its pages. Facsimile 1, according to Joseph Smith, was a drawing of an attempt to sacrifice Abraham, yet Egyptologist Richard Parker of Brown University, on examination of the original papyrus scroll from which it was copied by Joseph Smith, observes that the illustration simply represents a well-known scene from the *Book of Breathings* (Ropp (1987), p. 89). The text and scene are pagan and cannot be associated with Abraham. From an examination of a copy of the *Book of Breathings* in the British Museum it is also probable that facsimile 3 was attached to the same original papyrus scroll by a piece of papyrus that is now missing (Ropp (1987), p. 87). A modern interpretation of facsimile 2 bears no resemblance to Joseph Smith's interpretation, and Ropp (1987) concludes (p. 89): 'It is hard to reach any other conclusion than that Joseph Smith's explanations were products of his creative imagination'. It is interesting to note that, in connection with the Mormon murders and forgeries perpetrated by Mark Hofmann during the 1980s, Hofmann judged the importance of facsimile 2 to be such that it merited an attempt to forge the original (see Sillitoe and Roberts (1988)).

The overwhelming evidence, therefore, suggests that the *Book of Abraham* was a product of the mind of Joseph Smith, yet Mormon apologists still cling to the view that he was given the ability to translate the *Book of Abraham*, and that the *Pearl of Great Price* is as divinely inspired as the *Bible*. Brodie (1971), p. 423, points out that Mormons tend to advance the argument that the actual papyri from which Joseph Smith made his translation have yet to be discovered. It has also been suggested (Ropp (1987), p. 91) that the Egyptian text was a 'super-cryptogram' to which Joseph was given the key by direct revelation, despite the fact that the introduction to the *Book of Abraham* still maintains that it was 'Translated From The Papyrus, By Joseph Smith' (*Pearl of Great Price*, p. 29). Another proposition (Tanner and Tanner (1980), pages 353–354) is that the Egyptian text was a 'memory device', each character relating to a set number of phrases concerning Abraham's life, to which only Joseph Smith was given the key.

The *Book of Abraham* is thus directly relevant to any authorship study of the *Book of Mormon*. (Tanner and Tanner (1980), p. 363, note the difficulty facing the Mormon Church: 'The Mormon leaders cannot repudiate the *Book of Abraham* without seriously discrediting the validity of the *Book of Mormon*.') Its text was accordingly edited from the *Pearl of Great Price* textual database and transferred to a computer file.

5. ANALYSIS

The 24 textual samples described in the previous section were run individually on the Oxford concordance program, the results being fed into 24 different output files

each containing a lengthy word list in ascending order of frequency together with the summarizing vocabulary statistics. Both Yule (1944) and Sichel (1975) recommend that, when modelling vocabulary distributions, words of only one particular class should be considered. If models are fitted to vocabulary distributions containing all classes of words, including nouns, verbs, adjectives, pronouns, prepositions and conjunctions, then the fit will be affected by such anomalies as are inherent when different statistical populations are superimposed on each other. Tail frequencies, in particular, could be badly affected. In this study it is thus proposed to conduct that part of the stylometric analysis involving the measuring of Sichel distribution parameters α and θ on the observed vocabulary distributions for nouns only. All nouns will be counted, including proper, collective, common and abstract nouns. A partial lemmatization will also be undertaken, namely the subsuming of singular and plural forms. The objective of this study is to *compare* the 24 textual samples, not to establish their absolute values on some stylometric scale, so such decisions are justified provided that they relate and are applied consistently to all samples under study.

From each word list, therefore, nouns were manually tagged, lemmatized and extracted into separate vocabulary distributions. The 24 distributions obtained were

TABLE 2
Vocabulary distribution of nouns and Sichel parameters

Occurrences	*Joseph Smith 1 (J1)*	*Joseph Smith 2 (J2)*	*Joseph Smith 3 (J3)*	*Nephi 1 (N1)*	*Nephi 2 (N2)*	*Nephi 3 (N3)*	*Jacob (JB)*	*Lehi (L1)*
1	264	213	237	131	127	153	161	108
2	96	78	91	50	56	59	71	44
3	38	33	29	31	30	25	38	28
4	26	18	12	19	10	17	24	18
5	11	14	11	11	18	8	13	9
6	13	8	13	7	6	8	6	9
7	5	9	4	8	4	2	11	5
8	6	4	4	3	4	9	3	6
9	2	0	4	6	2	7	7	4
10	3	4	3	1	2	6	5	1
11	0	4	2	4	4	4	1	3
12	3	0	3	4	3	5	0	2
13	2	1	2	3	1	2	2	2
14	2	1	2	4	2	3	2	0
15	0	1	1	2	1	1	3	0
>15	6	8	9	24	17	18	17	8
V	477	396	427	308	287	327	364	247
N	1189	1102	1189	1669	1259	1577	1516	873
χ^2	4.67	3.59	12.39	4.31	10.61	12.78	9.19	2.17
Degrees of freedom	8	8	8	9	8	9	9	7
$P(\chi^2)$	0.80	0.89	0.13	0.89	0.23	0.17	0.42	0.95
α	0.501506	0.485894	0.344992	0.654980	0.709646	0.532813	0.738919	0.988850
θ	0.897312	0.920144	0.930821	0.982587	0.959080	0.975334	0.959044	0.931681
10000-α	1.426068	1.475177	1.015009	1.844295	2.201290	1.530240	2.085657	3.403547
10000-θ	0.987300	0.991336	0.992008	0.997804	0.995747	0.997010	0.994859	0.994233

arranged in identical groupings for comparability and the SICHEL computer program was then run on each resultant data set. Tables 2–4 give the vocabulary distribution of nouns, the χ^2 goodness-of-fit measures, estimates of the Sichel parameters α and θ, and their 10000-equivalent values, for the 24 textual samples. It will be seen from the χ^2-values in Tables 2–4 that, with the exception of Isaiah 1, we cannot reject the null hypothesis that the observed distributions fit the Sichel model. In many cases the fit is extremely good. The fit for Isaiah 1 was $P(\chi^2) = 0.03$, not too surprising, perhaps, since 24 χ^2-statistics have been examined, but it was decided to retain this sample since only two of the five variables to be measured in the multivariate analysis come from the Sichel model. Any abnormal behaviour exhibited by Isaiah 1, however, might be attributed to its less reliable estimates of α and θ arising from this poor fit.

Table 5 lists the values of K, R and V_2/V for the textual samples. It was more practicable to evaluate K for the vocabulary distributions of nouns only, but for the remaining two variables values of N, V, V_1 and V_2 are readily available from the Oxford concordance program output files so both R and V_2/V were calculated using the *total* vocabulary distributions. As a check against any dependence on text length all five variables were correlated against text length N. The correlation coefficients obtained were not significant.

TABLE 3
Vocabulary distribution of nouns and Sichel parameters

Occurrences	*Moroni 1 (R1)*	*Moroni 1 (R2)*	*Mormon 1 (M1)*	*Mormon 2 (M2)*	*Mormon 3 (M3)*	*Mormon 4 (M4)*	*Mormon 5 (M5)*	*Alma 1 (A1)*
1	139	165	149	162	140	140	138	152
2	66	69	59	62	66	55	62	65
3	32	39	28	40	35	26	39	31
4	26	24	23	24	14	27	36	15
5	22	12	9	18	16	14	13	18
6	20	12	7	11	14	10	8	15
7	9	5	9	10	13	6	8	9
8	10	9	5	3	4	7	5	3
9	8	4	9	9	6	8	2	2
10	3	5	3	3	6	5	5	6
11	3	2	5	6	4	2	6	5
12	2	1	3	3	1	0	5	6
13	0	3	1	1	4	3	4	1
14	2	2	3	3	3	4	2	2
15	3	2	2	7	6	4	3	1
>15	22	28	24	22	25	20	27	22
V	367	382	339	384	357	331	363	353
N	1961	1857	1948	1981	1924	1860	1987	1736
χ^2	12.18	5.32	6.84	6.48	7.64	7.34	13.96	9.95
Degrees of freedom	10	9	9	9	9	9	10	9
$P(\chi^2)$	0.27	0.80	0.65	0.68	0.57	0.60	0.17	0.35
α	1.141739	0.648412	0.718937	0.769133	0.868429	0.745673	1.006347	0.740915
θ	0.961849	0.976654	0.969060	0.974111	0.976545	0.976674	0.973142	0.971081
10000-α	2.971547	1.703386	1.963947	1.979093	2.239233	2.060509	2.583165	2.017354
10000-θ	0.994368	0.996617	0.995854	0.996090	0.996472	0.996945	0.995924	0.996099

TABLE 4
Vocabulary distribution of nouns and Sichel parameters

Occurrences	*Alma 2 (A2)*	*Doctrine and Covenants 1 (D1)*	*Doctrine and Covenants 2 (D2)*	*Doctrine and Covenants 3 (D3)*	*Isaiah 1 (I1)*	*Isaiah 2 (I2)*	*Isaiah 3 (I3)*	*Book of Abraham (AB)*
1	143	102	198	170	375	280	289	105
2	64	48	78	67	139	107	101	47
3	29	38	24	46	53	46	56	30
4	19	26	26	23	42	19	36	11
5	13	12	16	25	23	16	28	18
6	9	10	18	10	30	12	14	9
7	5	3	13	4	8	9	10	5
8	5	3	4	2	4	8	10	6
9	3	3	6	4	11	7	5	6
10	4	3	5	3	12	5	7	3
11	6	5	2	5	3	5	5	2
12	5	1	1	2	5	4	3	4
13	1	2	1	3	3	1	3	1
14	4	2	2	1	1	3	5	2
15	2	5	1	3	2	6	3	2
>15	20	24	28	21	24	27	24	11
V	332	287	423	389	735	555	599	262
N	1617	1615	1817	1631	2636	2176	2308	1144
χ^2	3.62	11.93	15.67	14.10	21.80	7.86	4.65	6.66
Degrees of freedom	9	9	9	9	11	10	10	9
$P(\chi^2)$	0.93	0.21	0.07	0.12	0.03	0.64	0.91	0.67
α	0.716309	1.002977	0.531285	0.804515	0.484177	0.323683	0.548195	1.083522
θ	0.973955	0.976672	0.974447	0.960180	0.950912	0.972832	0.954090	0.951149
10000-α	2.010842	2.844280	1.364516	2.157940	1.025776	0.758587	1.227337	3.417193
10000-θ	0.996695	0.997099	0.996126	0.994465	0.989063	0.995054	0.990841	0.995089

5.1. *Hierarchical Cluster Analysis*

Fig. 1 shows the dendrogram computed by applying a single-linkage cluster analysis to the 24-sample and five-variable data set. The metric employed was the Euclidean metric

$$1 - \left(\frac{x_r - x_s}{\text{range}}\right)^2$$

and the measure of similarity between individuals r and s is formed by summing these values for each variable and then dividing by the number of variables, i.e. 5. Chatfield and Collins (1980) have compared single-linkage clustering with other hierarchical clustering methods and conclude that single-linkage is the method of greatest mathematical appeal and has several computational advantages. However, it has the property of forming large clusters relatively quickly but, against this, it will also rapidly highlight individuals who are different from the others. Only the single-linkage method was employed in this study. Tables 6–8 list the similarity matrix

TABLE 5
Values of K, R and V_2/V for the textual samples

Text	*K*	*R*	V_2/V
Joseph Smith 1 (J1)	57.7	957.1	0.1545
Joseph Smith 2 (J2)	82.1	873.4	0.1601
Joseph Smith 3 (J3)	78.6	952.3	0.1582
Nephi 1 (N1)	145.2	684.0	0.1808
Nephi 2 (N2)	155.2	728.9	0.1648
Nephi 3 (N3)	150.5	733.8	0.1651
Jacob (JB)	134.3	732.6	0.1692
Lehi (LI)	109.4	667.0	0.1682
Moroni 1 (R1)	131.5	703.2	0.1649
Moroni 2 (R2)	115.7	746.0	0.1524
Mormon 1 (M1)	183.8	728.9	0.1829
Mormon 2 (M2)	132.7	735.4	0.1577
Mormon 3 (M3)	119.2	757.3	0.1507
Mormon 4 (M4)	168.9	740.6	0.1530
Mormon 5 (M5)	125.5	734.3	0.1619
Alma 1 (A1)	149.0	721.0	0.1565
Alma 2 (A2)	150.6	711.7	0.1605
Doctrine and Covenants 1 (D1)	126.9	625.5	0.1478
Doctrine and Covenants 2 (D2)	91.6	759.7	0.1505
Doctrine and Covenants 3 (D3)	98.9	764.1	0.1605
Isaiah 1 (I1)	81.3	833.4	0.1757
Isaiah 2 (I2)	114.2	816.0	0.1694
Isaiah 3 (I3)	90.9	793.7	0.1731
Book of Abraham (AB)	146.4	668.4	0.1675

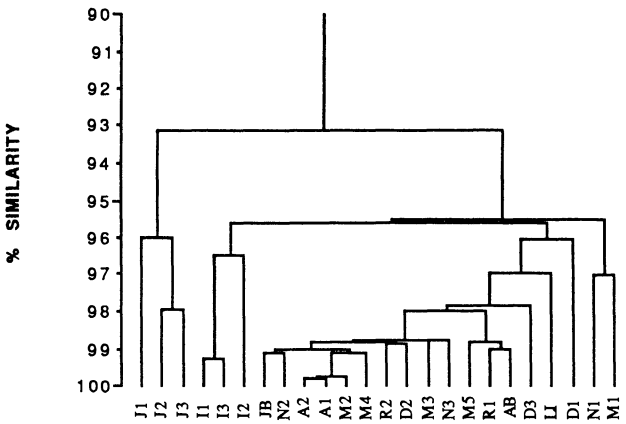

Fig. 1. Dendrogram for the total data set

underlying this particular analysis. It will be seen that, at around 96% similarity, the three samples of Joseph Smith's personal writings (J1, J2 and J3) have combined to form a cluster, as have the three samples of Isaiah from the *King James Bible* (I1, I2 and I3). All the *Book of Mormon* prophets, the *Book of Abraham* and Joseph Smith's revelations as recorded in *Doctrine and Covenants* have also combined in a large grouping, with the exception of Nephi 1 (N1) and Mormon (M1) which have

TABLE 6
Similarity matrix between textual samples

	J1	*J2*	*J3*	*N1*	*N2*	*N3*	*JB*	*LI*
J1	1.000							
J2	0.9603	1.000						
J3	0.9540	0.9789	1.000					
N1	0.4487	0.6993	0.6280	1.000				
N2	0.6506	0.8346	0.7667	0.9374	1.000			
N3	0.6150	0.8172	0.7754	0.9492	0.9831	1.000		
JB	0.6778	0.8555	0.7853	0.9550	0.9911	0.9740	1.000	
L1	0.6794	0.8232	0.6999	0.8530	0.9208	0.8545	0.9450	1.000
R1	0.5596	0.7365	0.6285	0.8733	0.9357	0.8779	0.9466	0.9577
R2	0.6963	0.8509	0.8145	0.8502	0.9453	0.9543	0.9385	0.8574
M1	0.4186	0.6655	0.5890	0.9706	0.9338	0.9231	0.9358	0.8281
M2	0.6546	0.8282	0.7723	0.9007	0.9781	0.9704	0.9720	0.9028
M3	0.6646	0.8126	0.7616	0.8200	0.9340	0.9193	0.9270	0.8746
M4	0.5678	0.7569	0.7057	0.8582	0.9659	0.9583	0.9337	0.8348
M5	0.6087	0.7824	0.7037	0.8932	0.9557	0.9233	0.9635	0.9347
A1	0.6263	0.8086	0.7485	0.8956	0.9840	0.9742	0.9669	0.8917
A2	0.6007	0.7979	0.7363	0.9282	0.9901	0.9856	0.9773	0.8940
D1	0.4841	0.6706	0.5716	0.7756	0.8893	0.8570	0.8747	0.8697
D2	0.7482	0.8787	0.8581	0.7980	0.8982	0.9205	0.8996	0.8167
D3	0.7689	0.9003	0.8427	0.8740	0.9522	0.9330	0.9688	0.9394
I1	0.8131	0.9315	0.9076	0.8675	0.8751	0.8864	0.9181	0.8443
I2	0.7213	0.8828	0.8812	0.8997	0.9119	0.9549	0.9255	0.7803
I3	0.7921	0.9272	0.8891	0.9057	0.9207	0.9259	0.9555	0.8908
AB	0.5411	0.7295	0.6072	0.8888	0.9477	0.8844	0.9530	0.9696

combined separately. It is interesting that, within this main cluster, there is no pattern to the subgrouping. With the exception of Alma, samples of text from individual prophets do not group together. Nor do the three samples from *Doctrine and Covenants*; indeed the nearest neighbour to sample D2 is the second sample from Moroni (R2).

We may conduct a deeper investigation into the structuring of this large cluster by omitting the Joseph Smith and Isaiah samples and recomputing the dendrogram. The result of this exercise is shown in Fig. 2. It is immediately noticeable that sample D1 now appears as an outlier. At around 93% similarity there is a large main group, the small group comprising samples N1 and M1 detected earlier, and sample D1 on its own. Within the main group there is once again no pattern to the subgrouping, Alma excepted. The other two samples from *Doctrine and Covenants*, D2 and D3, are not closely similar. Although Lehi (LI) stands slightly apart in this main group, the other prophet for whom we have only one sample, Jacob (JB), is in the middle of the cluster and has Nephi (N2) as nearest neighbour.

5.2. *Principal Components Analysis*

A principal components analysis was also carried out on the 24×5 data matrix under study, the variables being scaled to possess zero mean and unit variance. Some of the variables are quite highly correlated, which justifies the use of this technique. The variables also appear to be approximately normally distributed, with the

TABLE 7
Similarity matrix between textual samples

	R1	*R2*	*M1*	*M2*	*M3*	*M4*	*M5*	*A1*
R1	1.000							
R2	0.8894	1.000						
M1	0.8569	0.7871	1.000					
M2	0.9441	0.9871	0.8625	1.000				
M3	0.9318	0.9847	0.7695	0.9858	1.000			
M4	0.9040	0.9615	0.8500	0.9795	0.9631	1.000		
M5	0.9873	0.9453	0.8605	0.9796	0.9722	0.9427	1.000	
A1	0.9338	0.9788	0.8713	0.9956	0.9753	0.9915	0.9668	1.000
A2	0.9340	0.9703	0.9035	0.9928	0.9611	0.9847	0.9657	0.9968
D1	0.9295	0.9310	0.7141	0.9452	0.9609	0.9295	0.9458	0.9436
D2	0.8248	0.9875	0.7096	0.9524	0.9563	0.9093	0.8958	0.9366
D3	0.9427	0.9705	0.8213	0.9772	0.9706	0.9197	0.9724	0.9580
I1	0.7860	0.8568	0.8141	0.8576	0.8077	0.7655	0.8316	0.8286
I2	0.7665	0.9122	0.8486	0.9023	0.8476	0.8547	0.8378	0.8892
I3	0.8465	0.9016	0.8534	0.9077	0.8616	0.8271	0.8855	0.8842
AB	0.9898	0.8657	0.8887	0.9298	0.8989	0.8980	0.9664	0.9292

TABLE 8
Similarity matrix between textual samples

	A2	*D1*	*D2*	*I1*	*I2*	*I3*	*AB*
A2	1.000						
D1	0.9285	1.000					
D2	0.9256	0.8838	1.000				
D3	0.9538	0.9098	0.9552	1.000			
I1	0.8444	0.6702	0.9168	0.9168	1.000		
I2	0.9046	0.7179	0.9169	0.9058	0.9585	1.000	
I3	0.8979	0.7525	0.9035	0.9512	0.9934	1.000	
AB	0.9338	0.9090	0.7941	0.9512	0.7789	0.8417	1.000

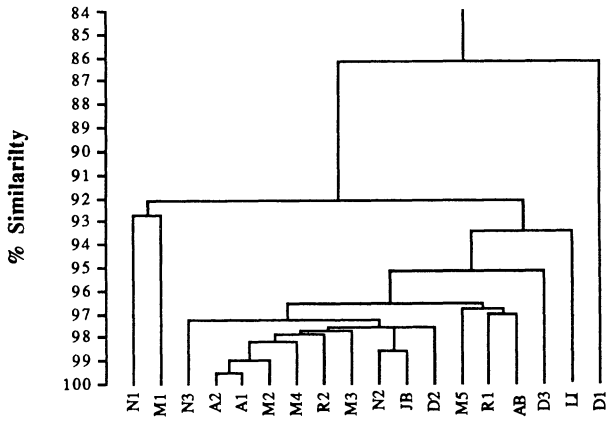

Fig. 2. Dendrogram for the prophet samples

exception of θ, which is negatively skewed. The proportion of the variability in the data accounted for by the five principal components derived is

PC1	PC2	PC3	PC4	PC5
55.0%	21.9%	15.5%	5.6%	2.0%.

Hence projecting the samples into the space of the first two principal components accounts for 76.9% of the total variation.

Fig. 3 shows the 24 textual samples plotted in the space of the first two principal components. The grouping structure highlighted by the dendrograms is again evident, but now we can see that it is the first principal component which is separating out the Joseph Smith and the Isaiah texts, whereas it is the second principal component which is pulling samples N1 and M1 and, to some extent, the Isaiah texts as well, away from the main cluster. To see what role the variables are playing in this clustering, we can

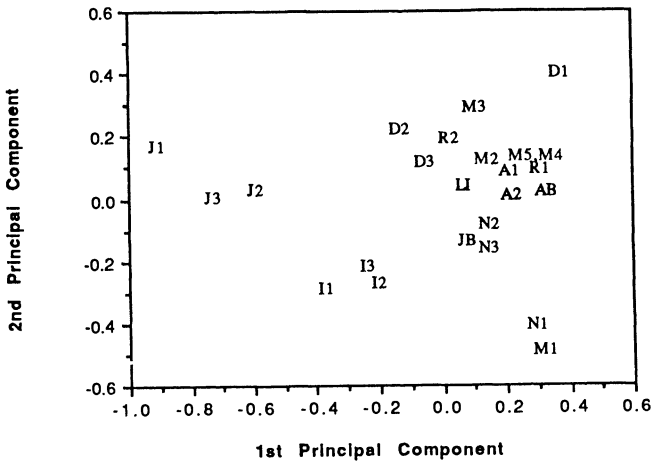

Fig. 3. Textual data in the space of the first two principal components

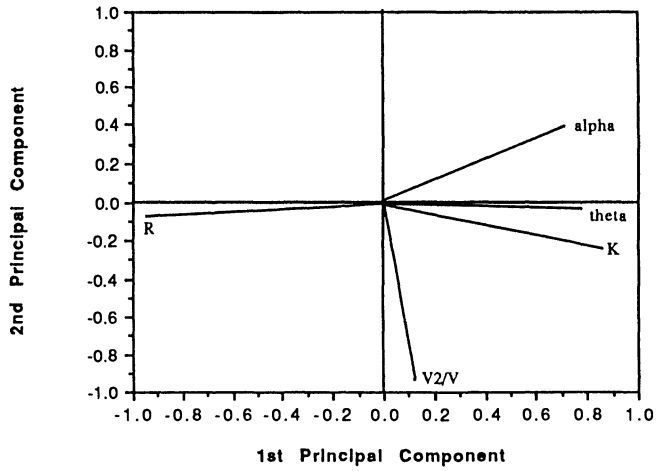

Fig. 4. Scaled loadings plot

TABLE 9
Correlation matrix between variables and principal components

Parameter	α	θ	K	R	V_2/V
α	1.0000				
θ	0.3811	1.0000			
K	0.4193	0.7697	1.0000		
R	−0.7250	−0.7634	−0.7079	1.0000	
V_2/V	−0.0755	−0.1351	0.2305	−0.0922	1.0000
PC1	0.7067	0.7766	0.8604	−0.9459	0.1176
PC2	0.3915	−0.0388	−0.2405	−0.0744	−0.9353
PC3	0.5656	−0.5685	−0.1402	−0.1335	0.3070

study the scaled loadings plot in Fig. 4. It is seen that the first principal component is a composite of variables α, θ, K and R, whereas V_2/V plays a dominant role in the second dimension. Indeed, from the correlation matrix given in Table 9, it is evident that 87.5% of the variation in V_2/V projects along the second principal component.

The third principal component accounts for 15.5% of the total variation in the data. Fig. 5 shows the 24 textual samples plotted in the space of the first and third principal components. The third component appears to be pulling samples LI, AB and R1 away from the remaining samples. The corresponding scaled loadings plot (Fig. 6) reveals that variables α and θ are dominant in this dimension.

We may summarize the principal components analysis, therefore, by noting that the clustering revealed by the dendrograms occurs again in the space of the first two principal components, which together account for 76.9% of the total variation in the data. Since the first component is a composite of α, θ, K and R whereas the second component is dominated by V_2/V, it would now be useful to investigate potential redundancy among the variables by seeing whether this grouping occurs on plots

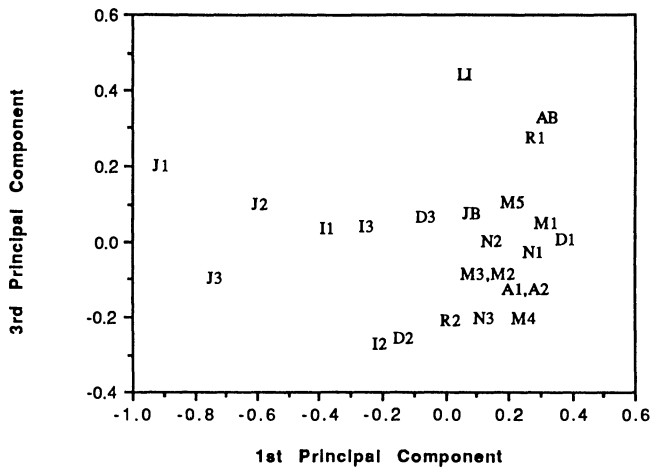

Fig. 5. Textual data in the space of the first and third principal components

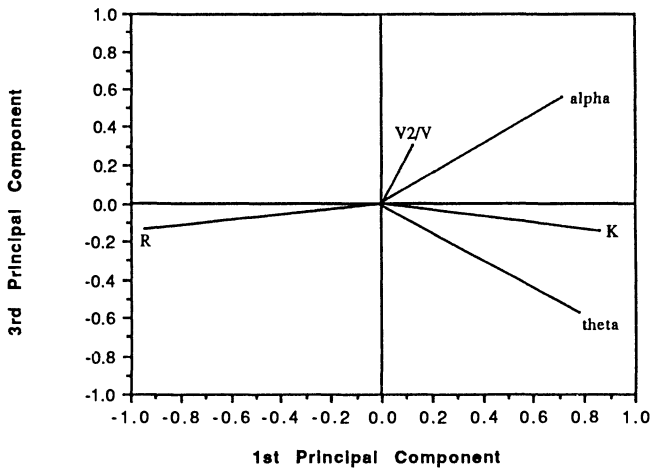

Fig. 6. Scaled loadings plot

involving just two of the five original stylistic variables. This would give us a deeper insight into the features causing the group structure.

5.3. *Two-variable Plots*

It would be interesting to begin this bivariate scrutiny of the textual data by conducting the transformation and plot advocated by Pollatschek and Radday (1981). This plot involves only the 10000-equivalent values of α and θ, referred to here simply as α and θ. Computed values of θ approach 1 very closely so that even a small variation may imply a considerable difference in vocabulary concentration. In contrast, α, which typically falls between 0.5 and 3, needs to record rather greater variations if it is to distinguish between levels of richness of vocabulary. To overcome this asymmetry, Pollatschek and Radday (1981) recommend transforming these two

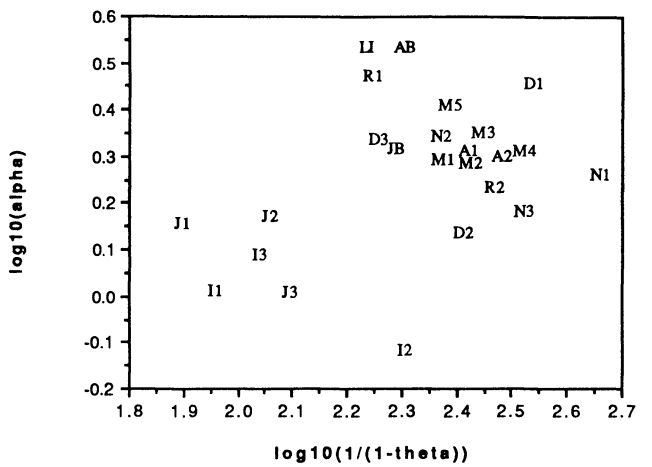

Fig. 7. Textual data in the space of the transformed Sichel parameters

parameters, thus making them more commensurable. They opt for $\log \alpha$, and for $\log\{1/(1-\theta)\}$ instead of θ.

Fig. 7 shows the textual data plotted in the space of the transformed values of α and θ. Although the Joseph Smith and Isaiah samples have pulled away from the main cluster, this plot has failed to highlight any differences between them. The plot also suggests that the *Book of Abraham* and the Lehi and Moroni 1 samples form a small group slightly apart from the main prophet group, in contrast with the positioning of these three texts on the preceding figures. Clearly this plot has limitations compared with the five-variable approach.

From the scaled loadings plot in Fig. 4 we can see that plotting V_2/V against either θ, K or R may give us the same grouping structure as obtained by using all five variables. Variables θ and K are positively correlated so it may not matter which of these two we choose. Figs 8 and 9 show θ against V_2/V and K against V_2/V

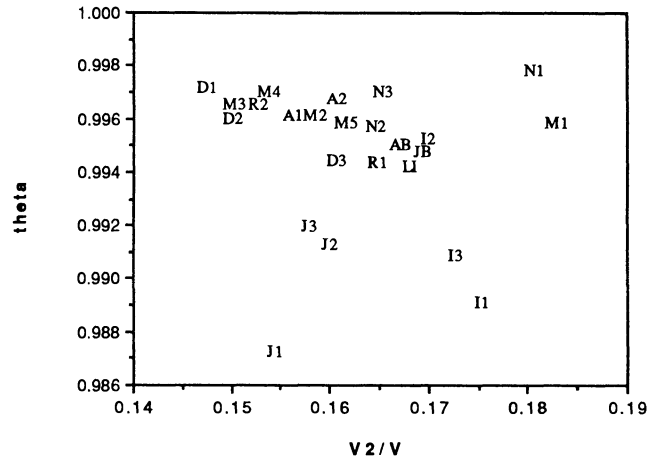

Fig. 8. Plot of Sichel parameter θ against the proportion of *hapax dislegomena*

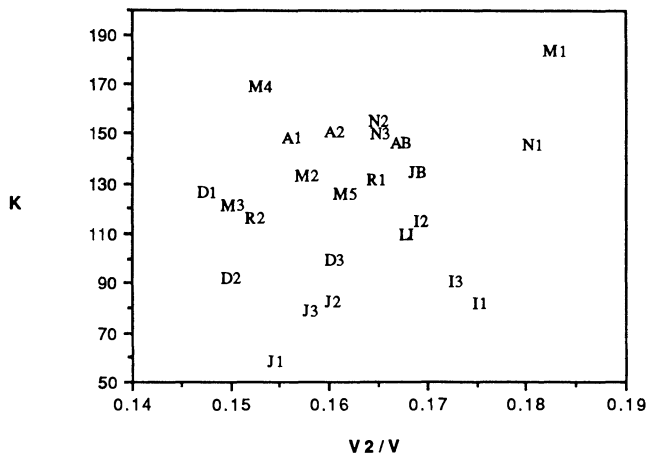

Fig. 9. Plot of Yule's K against the proportion of *hapax dislegomena*

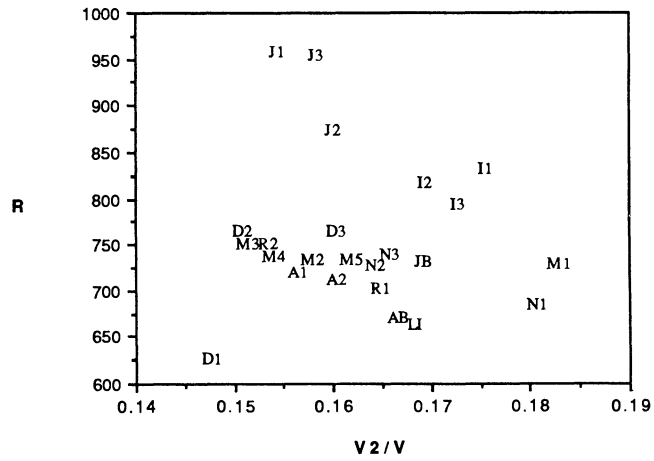

Fig. 10. Plot of Honoré's R against the proportion of *hapax dislegomena*

respectively. Whereas θ clearly pulls the Joseph Smith and the I1 and I3 samples away from the main cluster, the plot of Yule's K does not succeed at all in conveying an impression of clustering except, perhaps, samples N1 and M1 being outliers. Neither of these plots would be an adequate bivariate substitute for the five-variable plots illustrated previously.

We can now turn to Honoré's R-variable and assess its role as an effective discriminator. From Fig. 4 we see that R is negatively correlated with both θ and K, and, from Table 9, that 89.5% of the variation in R projects along the first principal component. Fig. 10 shows the plot of R against V_2/V. It is immediately apparent that this particular two-dimensional representation conveys the grouping pattern discovered by the multivariate clustering and principal component approach extremely well. For characterizing the differences between the textual samples, therefore, only variables R and V_2/V need to be computed and plotted. The other three variables are potentially redundant for revealing this particular discrimination.

6. CONCLUSIONS

We may summarize by noting that the analyses have shown that the Joseph Smith and Isaiah samples form distinct and separate clusters, whereas all other samples tend to cluster together.

There are three outliers to this general observation: samples D1, N1 and M1. The features causing this clustering are predominantly the observed proportions of *hapax legomena* and *hapax dislegomena* in the textual samples, as measured by variables R and V_2/V. It is this particular aspect of literary style which explains the grouping pattern. It would be an exciting prospect to bring these two variables to the fore in future research in stylometry.

The formation of the clustering observed here provides evidence of the utility of the multivariate technique advocated by this study. If we take the English text of *Isaiah* as used in this research as being in the *King James Bible* style then the clear distinction

between the Isaiah cluster and the main Mormon prophet cluster runs counter to Ropp's (1987) assertion (p. 50) that the *Book of Mormon* was written in the *King James Bible* style.

An important discovery is the fact that the samples of writings from the various prophets who purportedly wrote the *Book of Mormon* do not form prophet-by-prophet clusters. The dendrogram in Fig. 2 shows that only the two samples from Alma display internal homogeneity. Alma is not claimed to be an engraver of the golden plates; *all* his words are taken from Mormon's writings. The two samples which are closest to the Alma samples in terms of similarity are samples of Mormon's words taken from the so-called *Book of Alma* within the *Book of Mormon*. There appears to be no real difference between Alma's richness of vocabulary and Mormon's richness of vocabulary within the *Book of Alma*, a conclusion in direct contradiction to the findings of Larsen and the Brigham Young University team who state (Larsen *et al.* (1980), p. 240) that since, in their analysis, Alma's writing is different from Mormon's:

> 'We can conclude that Mormon copied directly from Alma's writings and Joseph Smith translated literally from Mormon's writings'.

The Brigham Young team did admit (Larsen *et al.* (1980), p. 242) that they found Moroni 'consistently hard to classify', unlike other prophets. The plots in this study show the two Moroni samples to be in the middle of the prophets cluster, yet they are not close in terms of similarity. This study has therefore not found any evidence of multiple authorship within the *Book of Mormon* itself. Variation within samples from the same prophet is generally as great as any variation between the prophets themselves.

The next important question that we must address is where the samples from Joseph Smith's revelations lie compared with the other samples. *Doctrine and Covenants* purports to be the collection of revelations given directly from God to Joseph Smith. These revelations were received in answer to prayer, in times of need, when the prophet and his associates sought for divine guidance. All the plots obtained from this research show that the samples of Joseph Smith's revelations do not form a separate homogeneous cluster in the manner of his own writings or of the *King James Bible*. Samples D2 and D3 fall within the prophets cluster and display the same richness of vocabulary as the prophets themselves, yet are not directly paired together. Sample D1 lies apart from this main group, having a much lower proportion of both *hapax legomena* and *hapax dislegomena* than any other sample. It is interesting that D1 comprises the earliest revelations of all, revelations received in 1828 and 1829. In terms of richness of vocabulary, therefore, two of the three revelations samples are indistinguishable from the *Book of Mormon* prophets. Because the prophets themselves are indistinguishable, this finding lends weight to the conclusion that either the *Book of Mormon* and the revelations are of divine origin, being the Word of God, or, if of human origin, they are the prophetic voice of Joseph Smith. To clarify this we must now turn to what I contend is the pivotal textual sample in the analysis: the text of the *Book of Abraham*. The *Book of Abraham* is unique among the Mormon scriptures in purporting to be a translation of ancient records that are extant and available for examination. It is the only work which came from Joseph Smith that we can study in the light of the original source. Ropp (1987), p. 80, states that 'the evidence against the *Book of Abraham* is by itself so damaging that we can be certain

the book is an invention of Joseph Smith's imagination'. The Brigham Young team, remarkably, omits this text from its analysis. Taves (1984) goes to the other extreme of taking the text as a control measure of Joseph Smith's writing.

The dendrograms and principal components plots in this study place the *Book of Abraham* text firmly in the main prophets cluster, its nearest neighbour being sample R1 from Moroni. For richness of vocabulary, clearly the *Book of Abraham* is indistinguishable from the *Book of Mormon* prophets and from samples D2 and D3 of Joseph Smith's revelations. It differs in style from his personal writing, however, and from the profile of Isaiah, the other biblical entity that we have studied. We may consider the *Book of Abraham*, the purported authors of the *Book of Mormon* and Joseph Smith's revelations to be of similar style, therefore, with all the implications that this may have for Mormon doctrine.

Evidence discussed earlier has shown that the *Book of Abraham* bears no resemblance to the papyrus from which it was supposedly translated. The Mormon response that the papyrus text has nothing to do with the book but, rather, had acted as a stimulus on Joseph Smith who, under his influence, received the text of the *Book of Abraham* by revelation, is flawed. Verses 12–14 in the first chapter of the work contain the following statement: '. . . that you may have a knowledge of this alter, I will refer you to the representation at the commencement of this record . . . that you may have an understanding of these gods, I have given you the fashion of them in the figures at the beginning'. This cross-reference between the supposedly revelatory text and facsimile 1 in the document itself provides a *reductio ad absurdum* of the Mormon argument.

It is my conclusion, from the results of this research and the supporting historical evidence, that the *Book of Mormon* sprang from the prophetic voice of Joseph Smith himself, as did his revelations and the text of the *Book of Abraham*. There is little doubt that Joseph Smith was capable of speaking and dictating with a prophetic voice. Brodie (1971), p. 405, describes his evolution from a 'bucolic scryer, using the primitive techniques of the folklore of magic common to his area' to a talented religious innovator, a preacher–prophet, with a substantial and growing following. Roberts (1985) devotes a whole chapter to evidence concerning how Joseph Smith's almost mystical aura could sway and influence practically anyone who listened to him. We have seen that the style of his prophetic voice, as evidenced by the main cluster of the textual samples studied, differs from the style of his personal writings or dictations of a personal nature. This opens up fascinating prospects for research in stylometry, namely the exploration of how a person's prophetic or artistic voice differs in style or richness of vocabulary from his or her everyday vocabulary usage. A by-product of this research would be to look at how the style of *dictated* material differs from that of *written* material, within the same author's usage.

The evidence brought forward here should not be regarded as superseding that of the more traditional kind. In attribution of authorship, stylometric evidence must be weighed in the balance along with that provided by more conventional scholarship. Stylometry does, however, have a role to play despite the suspicions of those who mistrust the application of statistical and computing techniques to literature and to the analysis of texts.

The way forwards in problems of attribution of authorship lies in a combination of statistical techniques with more orthodox methods. If the computer reveals certain unusual quantifiable properties in a text, it is for the scholar in the field concerned to

identify the features which are producing these effects. It is appropriate to conclude with Kenny's (1986) timely reminder that:

> '. . . as the stylometrist's work progresses it will illumine a familiar landscape, rather than overturn beloved landmarks'.

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