The following discussion aims at illuminating metrical practices found in some representative examples of Latin hexameter poetry. We begin by subjecting long known data to a simple form of statistical analysis. Our first query is whether the metrical shape of one foot (i.e., whether it is a dactyl or a spondee) is statistically associated with the metrical shape of any other foot.

Figure 1 presents the data for Lucretius, *De Rerum Natura* 3. It shows the number of verses containing each of the sixteen possible arrangements of dactyl and spondee in the first four feet (1). If we group these data foot by foot, we find the following (*Dxxx* symbolises a metrical scheme specifying only a dactyl in the first foot, and so on) :

	Number	Percent		Number	Percent
Dxxx	816	74.8	*Sxxx*	275	25.2
xDxx	555	50.9	*xSxx*	536	49.1
xxDx	354	32.4	*xxSx*	737	67.6
xxxD	294	26.9	*xxxS*	797	73.1

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That is, 816 verses, which constitute 74.8 % of the book, contain a dactyl in the first foot and the remaining 275 verses, or 25.2 %, contain a spondee, and so on for the remaining feet.

We begin with the first two feet and we make the following assumption : if there is no statistical association between the first two feet, we shall expect it "to make no difference" to the second foot whether or not the first foot is a dactyl or a spondee, and vice versa. That is, since 50.9 % of all verses have a dactyl in the second foot, we shall expect that about 50.9 % of the 816 verses with a dactyl in the first foot will also have a dactyl in the second foot. We can calculate what this number would be :

$$0.509 \times 816 = 415.344$$

On the assumption of statistical independence, then, we should expect to find about 415 instances of dactyls in the first two feet ($DDxx$). In fact there are only 363.

Similarly, we should expect that about 50.9 % of the 275 lines with an initial spondee ($Sxxx$) would also have a dactyl in the second foot :

$$0.509 \times 275 = 139.975$$

Instead of the expected 140 cases of $SDxx$, there are in fact 192. Since there are 52 more instances of $SDxx$ than expected, and 52 less instances of $DDxx$ than expected, it would appear that our expectation has been mistaken and we conclude that the first and second feet are not statistically independent.

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By way of contrast, consider the second and third feet. On the assumption of statistical independence, we would expect that a dactyl in the third foot would occur in 32.4 % of the 555 lines containing a dactyl in the second foot :

$$0.324 \times 555 = 179.82$$

In fact there are 176 instances of *xDDx*. Just so, we should expect about 174 (0.374 x 536) instances of *xSDx* and there are in fact 178. The expected numbers are very close to the actual ones and it appears reasonable to conclude that the assumption of statistical independence need not be rejected here.

Figure 2 deals in greater detail with the relation between the first and second feet in *De Rerum Natura* 3 (*DRN3*). Figure 3 similarly deals with the second and third feet in the same work. The upper part of each figure consists of a "2 x 2 contingency table" in which all the possible combinations are set forth. Actual values are given accompanied by "expected" values placed within parentheses. For example, Figure 2 shows an expected value of (415) in the lower right hand "cell" as well as the actual value of 363 instances of *DDxx* (i.e., those instances which are simultaneously *Dxx* and *xDxx*). Such expected values are conveniently derived by multiplying the relevant column total (555) by the relevant row total (816) and dividing by the grand total (1091) :

$$\frac{555 \times 816}{1091} = 415.11$$

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The expected values in the other three cells are similarly derived. These are the values expected under the "null hypothesis," i.e., the assumption that the distribution of dactyls and spondees in the first foot is not influenced by the distribution of dactyls and spondees in the second, and vice versa.

It must be understood that the null hypothesis does not demand that we find exactly 415 instances of *DDxx*, but rather a number reasonably close to that figure, just as we should expect to find about 500 "heads" in 1000 tosses of an unbiased coin. A portion of elementary statistics is, however, devoted to the elucidation of what is meant by "reasonably close." Some events are less likely than others and these likelihoods are measured by *chi squared (X^2)*. In Figure 2, *chi squared* is equal to 51.81 with one degree of freedom. Its significance is set at 0.00000, which is very significant indeed. By contrast, *chi squared* in Figure 3 is 0.21 with significance set at 0.64, which is not significant at all.

While these concepts are explained in any text on statistics, they need further comment here. The process of crosstabulation, as presented in Figures 2 and 3, is notoriously used to deal with the following sort of question : are blue eyes and blonde hair statistically associated ? Suppose we were to select a random sample of 1091 people and found within it a distribution of characteristics equal to that in Figure 2 (assuming, for example, that *Dxxx* equals "blue-eyed" and *xDxx* equals "blonde-haired.") Our null hypothesis would be that blue-eyed people are no more likely to be blonde-haired than non-blue-eyed people. The significance level of 0.00000 tells us that if we were to repeat the sampling procedure 100,000 times and if in fact the null hypothesis

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were true, we should not expect to find a *chi squared* score as large as 51.81 even once. Either the null hypothesis must be rejected with more certainty than we usually have in this world, or there has been some error in the sampling procedure. If, on the other hand, the results are those of Figure 3, then the significance level of 0.64 indicates that a *chi squared* score as large as 0.21 will occur in up to 64 % of such sample drawings when the null hypothesis is true. Note that this does not prove that the null hypothesis is true; only that good grounds for rejecting it have not been found on the basis of this sample drawing. (After all, even a badly biased coin will occasionally turn up 5 heads in 10 tosses.)

How does the above discussion apply to our consideration of *DRN3* ? There is, after all, no well defined parent population from which the poem is drawn as a sample, and we are in any case more interested in the characteristics of *DRN3* than in drawing inferences from it about some putative parent population. One may hold, however, that *DRN3* represents a sample of sorts of the entire *De Rerum Natura*. It is worth noting that the statistical association between the first two feet is also found in the other five books ·(2). Alternatively (and this may be more prudent, given the degree to which sections of the same work may differ from each other), we may posit the parent population as the potential store in some sense of hexameter lines at Lucretius' disposal at the time or times he was composing *DRN3*. While our major concern remains descriptive rather than inferential, it is important and intrinsically interesting to know that the strength of the association found is such that if *DRN3* were a random sample of a parent population one could reject the null hypothesis of nonassociation for the population as a whole. The finding is also interesting because it is counter-intuitive. The second most popular

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metrical scheme in the work is *DDSS* and there are many instances of *DDDS* and *DDSD*. Nevertheless, *DRN3* does not contain as many instances of *DDxx* as might be expected.

We must be careful not to overinterpret the result and there are some con- clusions that we are not entitled to draw. First, it is not proper to conclude that the presence of a dactyl in the first foot *causes* an avoidance of dactyls in the second. An association is not the same as a relation between cause and effect. Second, the avoidance is not confined to *DDxx*. Consideration of Figure 2 shows that there is also significant avoidance of *SSxx* and significant preference for *SDxx* and *DSxx*. These findings are all interdependent. Given fixed row and column totals, the˜deviation in one cell determines the devia- tions in all the others. There are 52 fewer cases of *DDxx* than expected. Just so, there are 52 fewer cases of *SSxx* than expected and 52 more cases than expected of *SDxx* and *DSxx* respectively. (That is why one speaks of only one degree of freedom.) Given this interdependence, we cannot differen- tiate among the cells. All we can conclude is that similar feet in succession, are avoided and, concomitantly, that dissimilar ones are preferred. (3)

A final feature of Figures 2 and 3 requires explanation. *Chi squared* is used to see whether or not a real statistical association exists, that is, whether or not there are sufficient grounds to reject a null hypothesis. It should be in- tuitively clear that *chi squared* will be much affected by the length of the work under consideration. (For example, doubling the size of a sample will quadruple *chi squared*.) Since we shall be comparing hexameter works of dif- ferent length, we need a measure of association which is not affected by

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sample size. Kendall's *Tau beta* (4) (which we symbolize as *Tb*) is just such a measure. Samples of any size with identical characteristics will have the same *Tb* score. As a result *Tb* scores are used here to compare degrees of association in works of different length. As we shall see, it is quite possible for small texts to have low *chi squared* scores and quite high *Tb* scores. In such cases, we must say that the sample size is too small to justify rejecting the null hypothesis, but the description given by the *Tb* score is valid nonetheless. For the same reason of comparability, we shall report many of our findings in percentage form.

Figure 4 reports in abbreviated form the results obtained from crosstabulating the remaining four possible pairs of the first four feet in *DRN3*. It is apparent from Figures 2, 3 and 4 that the null hypothesis of statistical independence is to be rejected only for the combination of the first two feet. The null hypothesis represents a very "good fit" for the other five possible pairs. These results are reassuring in two ways. The good fit in five of the six cases indicates that the null hypothesis is a good and reasonable way of describing the general state of affairs. The unusual result for the first two feet indicates that something of interest is happening here. We thus reveal a hitherto unsuspected characteristic of Lucretius' metrical practice in *DRN3*. Through the elementary statistical analysis of data collected long ago and widely available, we now find that Lucretius preferred metrical variety in the first two feet of his verse. Even though three fourths of his first feet and one half of his second feet are dactyls, he avoided juxtaposing them, perhaps deliberately. He also avoided the juxtaposition of spondees in the first two feet. No such avoidance is detectable elsewhere in the line.

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This finding is of intrinsic interest, but it will be much increased by comparison with findings elsewhere. There are to be found in the Appendix. Within the bounds of this study, we shall be concerned with the comparison of rather more complicated findings from a small corpus of completely scanned hexameter texts in machine-readable form. The texts are :

Abbreviation	Work	Length
DRN3	Lucretius, De Rerum Natura 3	1091
Cul	Culex	414
Ecl	Vergil, Eclogues	830
Aen4	Vergil, Aeneid 4	705
Aen12	Vergil, Aeneid 12	952
Met12	Ovid, Metamorphoses 12	628
BC1	Lucan, Bellum Civile 1	690
BC10	Lucan, Bellum Civile 10	548
Arg1	Valerius Flaccus, Argonautica 1	849

While not a very large corpus, it is designed to be illustrative and instructive. The range in time from Lucretius to Valerius Flaccus is considerable. Differences among the Vergilian works or in Lucan are of interest and the Culex is a puzzle of long standing (5).

Figures 5 and 6 present in abbreviated form and in percentage terms the finding for the entire corpus corresponding to those already presented for DRN3. Figure 5 is less complicated and little comment is necessary. The first foot

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in all the works has the largest percentage of dactyls, running from a high of 81.4 % *(Met12)* to a low of 57.7 % *(Aen12)*. For the most part, the percentage of dactyls decreases as one goes through the line from the first foot to the fourth. *Arg1* is a glaring exception in its high percentage of *xxDx*. Perhaps the most instructive aspect of Figure 5 is the degree to which works by the same author differ. The percentage of *xDxx* in *Aen4* is very different from that in *Aen12.* Just so, the percentage of *xxxD* in *Ecl* differs greatly from those found in *Aen4* and *Aen12.* All this should be chastening to those who rely on such figures for purposes of attribution.

Figure 6 lists the results for three of the six possible combinations. We omit the findings for the relationships between feet which are not contiguous because they are less interesting from a statistical point of view. In no case is the *Tb* score for noncontiguous feet greater in magnitude than -0.10. This level is exceeded in seven out of nine cases for Feet 1 and 2 and in three out of nine cases for Feet 2 and 3 and for Feet 3 and 4. This seems to confirm the intuitive notion that such associations should be strongest between contiguous feet. The *Tb* score of -0.22 for Feet 1 and 2 in *DRN3* is equalled or surpassed at only two points : for Feet 1 and 2 in *BC1* and for Feet 2 and 3 in *BC10.* It is again chastening to note the disparity between *BC1* and *BC10* for Feet 1 and 2.

It is reasonable to conclude that the avoidance of *DDxx* and *SSxx* is found in all parts of the corpus although with varying degrees of intensity. *BC1, BC10,* and *Arg1* are curiously united in testifying to a very strong association for the third and fourth feet.

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This is as far as we choose to go with this well known sort of data. Unsuspected relationships are revealed for each work in the corpus and there is more in the Appendix. We move now to the second part of our study which is of necessity confined to the texts in the corpus, i.e., completely scanned texts in machine-readable form.

As young students of scansion know, the fifth and sixth feet of the hexameter line represent a haven of security after having traversed the uncertain seas of the first four feet. The fifth foot is almost always a dactyl and the prose stress or accent almost always falls upon the first syllable of the fifth foot. Similarly, the sixth foot will always consist of two syllables, indifferently a spondee or trochee, again with prose stress almost always falling upon the first syllable of the foot. In what follows, we wish to see whether this association of metrical form and prose stress is echoed elsewhere in the line. For this purpose, it is necessary to know where and how often such prose stress occurs and how often it occurs with dactyls and how often with spondees. Couting and classifying such features is best done by computer.

We are well aware that this is well trodden ground replete with pitfalls for the unwary. Nevertheless, our procedure has been brutally straightforward in its simplicity and we must view our results as no more than an initial approximation. Using the computer as we do, it has seemed reasonable to begin with uniform procedures which can later be modified if necessary or desirable. We have, therefore, applied absolutely automatic rules for the location of word accent or prose stress :

    1. All monosyllabic words are regarded as stressed.

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2. All bisyllabic words are accented on the first syllable.

3. Trisyllabic or longer words are accented on the penultimate syllable if long; otherwise on the antepenult.

4. Elision does not change the location of the accent.

5. Enclitics are considered an integral part of the word, whether elided or not. Thus *virumque* is accented on the second syllable whether the last syllable is elided or not.

6. No prodelision. *Notum est* is reckoned as if it were *not′ est* with two separate stresses.

All the above have been the subject of seemingly endless controversy and it is impossible to present adequately here a representative range of views(6). What can be said in defense of these rules is that they have been applied uniformly and consistently to all the works in the corpus. As a result, our findings are valid for purposes of comparison. It is also not likely that minor changes in these rules would greatly affect the findings.

There are lesser problems of nomenclature. We avoid such technical terms as "homodynamic" and "heterodynamic" and such value-laden terms as "harmony" and "clash", nor do the terms *ictus, arsis,* and *thesis* seem especially useful. When the prose accent falls upon the first syllable of the foot, we say that "initial stress" is present. Such initial stress is symbolized by *1;* its absence by *0.* For example, initial stress in the second foot is symbolized by *x1xx.* The absence of initial stress in Foot 3 is represented by *xxOx.*

Given our previous discussions, we may move quickly. A computer program

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was concocted which located all the prose stresses in our scanned texts. Statistics were then gathered for the presence or absence of initial stress in the first four feet of the line. These findings are presented in Figure 7.

It is noteworthy that the lowest percentages for *Ixxx* occur in *Aen4* and *Aen12* while the highest is found in *Ecl*. So much, once again, for attribution studies. In general, there is far more initial stress in Foot 1 than elsewhere. With the notable exception of *Arg1*, there is less initial stress in Foot 3 than elsewhere. Percentages for *xIxx* are not markedly different from those for *xxxI*; with two exceptions, *Ecl* and *Arg1*, percentages are a bit higher for the fourth foot (7).

Figure 8 reports findings for four of the six possible pairs of feet. The format and rationale are those of Figure 6 save that we deal here with initial stress rather than metrical shape. Consider first the findings for the combination of Feet 1 and 2. The *Tb* score exceeds 0.10 in only three cases : *DRN3, Aen12,* and very notably, *Ecl*. The *Tb* scores are almost all positive and, therefore, indicate that there are more cases of *OOxx* and *IIxx* than would be expected under the null hypothesis. This is a marked contrast to the other combinations where the *Tb* scores are decidely negative and indicate more cases of alternation than would be expected.

Data for the combination of Feet 1 and 3, the only combination of noncontiguous feet, has been included in our tabulations. In every case but one *(Aen4)*, *Tb* scores exceed -0.10. They are all negative, indicating more instances of *IxOx* and *OxIx* than expected. This statistical association is of considerable

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interest because it was previously unsuspected (at least by us), because it is so generally found, and because it seems to exist independently of any associations between Feet 1 and 2 and between Feet 2 and 3 (8).

The combinations of the second and third feet and of the third and fourth feet reveal very strong statistical associations. Were it not for the lack of association between Feet 2 and 3 in *DRN3*, one might have supposed that such association is an inescapable feature of the Latin hexameter. These associations are especially characterized by a striking avoidance of *x//x* and *xx//* which becomes more marked as one moves from left to right across the table. One finds *x//x* in 9.2 % of *DRN3* and in only 1.1 % of *BC10*. Similarly, *xx//* decreases from 8.9 % in *DRN3* to only 0.7 % in *Arg1*, and one may suspect with some force that *Cul* belongs in the vicinity of *Met12* or *BC10*. In any case, the decrease in percentage of *x//x* and *xx//* is very marked in Lucan and Valerius Flaccus, where a line like :

> miretur; sub te puerilia tela magistro (*Arg1* 269)

is a rare event indeed.

We turn now to the association between metrical shape and initial stress. We begin by considering in isolation the first foot in *DRN3*. As we know from Figures 5 and 7, 25.2 % of the lines contain *Sxxx* and 21.8 % contain *Oxxx* We now ask how many lines have a first foot which is both spondaic and without initial stress. An example of such a line would be :

> naturam rerum, divina mente coorta,   (*DRN3*.15).

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The null hypothesis of no statistical association between metrical shape and initial stress yield the following estimate :

$$1091 \times 0.252 \times 0.218 = 59.9$$

Under the null hypothesis we would expect to find about 60 cases of a first foot spondee without initial stress $(S^O xxx)$. In fact there are 100 lines of this sort. Similarly, there are 678 cases of $D^1 xxx$ in place of an expected 638. The null hypothesis is clearly to be rejected. Figure 9 contains the full table for Foot 1 and a summary in percentage form for both Foot 1 and Foot 2. The large *Tb* scores are positive, indicating a positive association of dactyls with initial stress and of spondees with the absence of such stress. The association is slightly stronger for Foot 2 than for Foot 1. In both feet, then, dactyls are significantly more likely to have initial stress than are spondees. This seems to be intuitively acceptable.

Figure 10 presents our findings for the coocurrence of metrical shape and initial stress within each foot for the entire corpus. In the case of Foot 1, the *Tb* score for the association of shape and stress rises from 0.21 for *DRN3* to a high of 0.36 for *Met12*. The positive association of dactyl with initial stress and of spondee with lack of stress continues unabated for Foot 2 and for Foot 3, with an overall high of 0.55 for Foot 3 in *BC10*. The first three feet in the entire corpus attest to a constant, strong association. It is, therefore, most interesting, provocative, and puzzling to find that to all intents and purposes this association disappears in Foot 4. To be sure, none of the *Tb* scores are negative, and they go as high as 0.13 for *Ecl* and 0.16 for *Arg1*, but they are very small in comparison for the figures found

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for the first three feet. This is the most surprising of all our general findings and we remain perplexed by it (9).

We now have four compounded ways of describing each foot : S^O, S^I, D^O, and D^I. As a result, when we turn once again to the association, if any, between the first and second feet, there are now sixteen different combinations. They are listed here together with an example of each from *DRN3* :

$S^O S^O xx$	discedunt, totum video per inane geri res (17)
$S^O S^I xx$	semota ab dulci vita stabilique videtur (66)
$S^O D^O xx$	aspergunt neque nix acri concreta pruina (20)
$S^O D^I xx$	infamemque ferunt vitam quam Tartara leti (42)
$S^I S^O xx$	at contra nusquam apparent Acherusia templa (25)
$S^I S^I xx$	cycnis, aut quidnam tremulis facere artubus haedi (7)
$S^I D^O xx$	qui primus potuisti inlustrans commoda vitae (2)
$S^I D^I xx$	noctes atque dies niti praestante labore (62)
$D^O S^O xx$	suppeditas praecepta, tuis ex, inclute, chartis (10)
$D^O S^I xx$	consimile in cursu possint et fortis equi vis ? (8)
$D^O D^O xx$	diffugiunt animi terrores, moenia mundi (16)
$D^O D^I xx$	laetitiaque viget, cum cetera pars animai (150)
$D^I S^O xx$	e tenebris tantis tam clarum extollere lumen (1)
$D^I S^I xx$	tu, pater, es rerum inventor, tu patria nobis (9)
$D^I D^O xx$	quas neque concutiunt venti nec nubila nimbis (19)
$D^I D^I xx$	quod te imitari aveo; quid enim contendat hirundo (6)

These sixteen different combinations allow us to move from "2 x 2" to a "4 x 4" contingency table. Figure 11 presents such a table for the first two

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feet of *DRN3*. An important advantage of the 4 x 4 table is that it posses-
ses nine degrees of freedom rather than one. Thus the numerical differences
between actual and expected values vary from cell to cell (whereas they must
be identical in 2 x 2 tables.) For example, the actual and expected values
for $S'D^Oxx$ are very close, but they differ greatly for $S'D'xx$. As a result,
we are able to discern where the major deviations occur. In our present
example, it is clear the $S'D'xx$ plays a greater role than any other because
the contribution of its cell toward the total *chi squared* score is greatest.
There are many more cases of $S'D'xx$ than would be expected under the
null hypothesis of statistical independence.

There is also a disadvantage in presenting our findings in the form of Figure
11. As we have seen in Figure 9, there is a strong association between me-
trical shape and initial stress *within* each of these two feet. The results of
that association are included in Figure 11 and are responsible for a part of
the noted deviations from expected values. In sum, the table in Figure 11
combines rather more information than we can deal with comfortably. We
choose instead, at this point in our investigation, to see whether the statistical
association between the metrical shapes of these feet persists even after we
have allowed for the presence or absence of initial stress.

Such allowance is made by sequestering all lines with a particular combination
of initial stresses. Figure 12 presents the 2 x 2 table for metrical shape in
lines *DRN3* with the pattern *OOxx*. The first point to be noted is that there
are only 160 such lines, making up 14.7 % of the work. Similarly, as the
summary in the lower half of Figure 12 shows, there are only 78 lines with

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Olxx or 7.1 % of the work. As a result, findings here will have only a minor impact upon our impressions of the work as a whole. In contrast, there are 450 lines with *IOxx* (41.2 %) and 403 lines with *IIxx* (36.9 %).

The second point to be noted emerges from a comparison of Figure 12 with Figure 2. Lines with *SSxx* constitute 7.6 % of *DRN3* as a whole, but they make up 14.4 % of the lines with *OOxx* and as little as 5.5 % of the lines with *IIxx*. This variation is not surprising, given the association between metrical shape and initial stress within each foot.

The third and most important point, however, is that even after we have made allowance for the presence or absence of initial stress, there may remain a significant degree of association. As the *Tb* scores at the bottom of Figure 12 show, there is avoidance of *SSxx* and *DDxx* in all combinations of initial stress, but the degree of avoidance varies. It is most marked in the lines with *IIxx*. This is our final and most important finding, and it exemplifies the advantage of this procedure, for it allows us to conclude that more interesting events are occurring in the case of *IIxx* than elsewhere.

We began this section of our discussion with the observation that the fifth and sixth feet of the hexameter line demonstrate uniform practices of the poets with regard to both metrical shape and initial stress. Feet 5 and 6 are contiguous feet with initial stress and with a sort of alternation in metrical shape (10). It seemed promising to assume that a tendency toward the same practices might be discernible elsewhere. That tendency has been perceived in the association between the first two feet in *DRN3*. This faint echo, as it

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were, of the last two feet may also help to account for another mystery of the hexameter line, the fact that the first foot is always more dactyllic than any other foot save the fifth.

It remains to be seen whether our assumption holds for other works and other combinations of feet. Figure 13 lists the data and findings for Feet 1 and 2 in the corpus. They are presented in percentage form on the model of the summary in Figure 12. We have already discussed the findings for *DRN3*.

The findings for *Cul* are even more striking since by far the strongest association of metrical shapes occurs in lines with *IIxx*. The only competitor is *OIxx* but this scheme is found in only 7.7 % of the lines and the *Tb* score is lower.

Our assumption is not upheld in *Ecl*. A higher degree of association is found for *OOxx* than for *IIxx*. Nevertheless, the *Tb* score of *IIxx* is significant and a larger percentage of lines is involved.

Findings for *Aen4* are unusual. In particular, a *positive Tb* score for *OOxx* is noteworthy. In these lines, constituting 20.3 % of the whole, there is a preference for *SSxx* and *DDxx*. All this, however, is heavily outweighed by the findings for *IIxx* where our assumption is amply upheld.

Our assumption is clearly not upheld in *Aen12*. *Tb* scores are all -0.19 except for *10xx* where it is smaller.

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Met12, BC1, and *BC10* support our assumption. It should be noted, however, that the tendency toward alternation of shape is accompanied here by a very marked avoidance of $S'S'xx$.

Arg1 has a high *Tb* score for *llxx*, but it has an even higher one for *Olxx*. The latter, however, constitute only 5.9 % of the work.

In sum, our assumption has been upheld in six of the nine works. In no case is there an insignificant *Tb* score for *llxx*. Stronger confirmation is provided by the *chi squared* scores which are far higher for *llxx* than for any other combination of initial stress (save for the anomalous *Aen12*.) We conclude therefore that aspects of the fifth and sixth feet are echoed to some degree in the first two feet (a) by a stronger preference for alternation of metrical shape when both feet have initial stress, and (b) by the large proportion of dactyls in the first foot.

When we turn to the other combinations of contiguous feet, the most salient factor is the very marked avoidance of simultaneous initial stress. Cases of *xllx* and *xxll*, as we know from Figure 8, are few, so few that, as a result, it is clear that our assumption is not properly applicable to these pairs of contiguous feet (11).

A summation of our findings follows :

First, there is almost never any tendency toward the repetition of metrical shape. Within the first four feet of the hexameter line, there is either a ten-

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dency toward alternation, i.e., a dactyl followed by a spondee or vice versa, or no significant tendency toward either alternation or repetition. The presence or absence of such tendencies and the comparative strength and locations of such tendencies, where they exist, are the bases for a valid and informative way of describing a part of the metrical practices of a particular work or poet.

Second, our findings concerning initial stress are subject to modification and refinement, since the location of such stress is to some degree uncertain. Nevertheless, our findings here are valid for comparative purposes because our rules for the placement of stress have been applied consistently to a number of different works and authors. With regard to the first two feet, there is no tendency toward the alternation of such stress, i.e., there is no tendency for a foot with initial stress to be followed by one without such stress and vice versa. In about half the works analyzed there is a modest tendency toward either the repeated presence or the repeated absence of stress in the first two feet.

Third, with regard to the second, third, and fourth foot, there is an increasing tendency toward the alternation of stress in successive feet as one moves from Lucretius forward in time to Valerius Flaccus.

Fourth, the combination of the first and third feet possesses a fairly constant tendency toward the alternation of initial stress.

Fifth, within each of the first three feet of the line, initial stress is much

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more likely to occur with dactyls than with spondees. This association practically disappears in the fourth foot. This finding seems to be generally true and it is puzzling.

Sixth, with regard to the first two feet, the tendency toward the alternation of metrical shape is most marked in those lines in which both these feet possess initial stress. This statement is true for six of the nine works examined. The tendency is, in any case, significantly present in the first two feet of all nine works. We surmise, therefore, that the first and second feet are to this extent a reflection or echo of the metrical practices found in the fifth and sixth feet. The avoidance of successive initial stresses in the second, third, and fourth feet forestalls such speculation in their case.

Our conclusion is brief. It should by now be clear that we have not been able to use all the statistical information available to us. We have had to make choices as we wandered in the maze of "output" generated by the computer, and it may well be that we have overlooked relations and tendencies of greater interest and significance than those we have noted. We believe that the associations revealed here will contribute to a richer and more firmly based comparison of poetic styles, but a saving grace of statistical method is its constant reminder that we are all prone to error (12).

OBERLIN COLLEGE   Nathan A. GREENBERG

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NOTES

(1)   Lists of this sort were, so far as I know, first published by
M. W. DROBISCH in *BSGL* 18 (1866) 75-39 and 20 (1868) 16-65.
See the discussion of Drobisch's work in C.B. WILLIAMS, *Style and
Vocabulary : Numerical Studies* (London : Charles Griffin, 1970)
116-124. Recent figures for this and much other hexameter poetry
have been presented by G.E. DUCKWORTH, "Studies in Latin Hexa-
meter Poetry," *TAPA* 97 (1966) 110-113. See also R.W. GARSON,
"Metrical Statistics of Valerius Flaccus' *Argonautica*," *CQ* 62 (1968)
376-379. The most complete account of Duckworth's work is given
in G.E. Duckworth, *Vergil and Classical Hexameter Poetry : A Study
in Metrical Variety* (Ann Arbor : Univ. of Michigan Press, 1969).
This contains a valuable bibliography of previous work. The data pre-
sented in this study are derived by computer from scanned texts in
machine-readable form.

(2)   The Appendix to this study contains findings about such associations
for a large number of hexameter poems, including Lucretius. These
findings are all based on metrical data gathered and published by
G.E. DUCKWORTH.

(3)   It is true that the percentage of deviation will differ for each cell

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and that, therefore, the contribution of each cell toward the total *chi squared* score will differ. Such differences will be utilized below, but only in a case where there is more than a single degree of freedom.

(4)   See N.H. NIE, C.H. HULL, J.G. JENKINS, K. STEINBRENNER, D.H. BENT, *SPSS : Statistical Package for the Social Sciences : Second Edition* (McGraw-Hill, 1975) 228, n. 1. For a 2 x 2 table, the formula for *Tb* reduces to that for *phi*, i.e., $(X^2/N)^{1/2}$ save that a minus sign indicates a preponderance of instances along the minor diagonal (from upper right to lower left). Note also that X^2 *(chi squared)* in the above formulation does not incorporate Yates' correction. An alternative formulation is given in the Appendix.

(5)   The texts of the *Culex* and of the *Eclogues* have been received from the American Philological Association Repository of Greek and Latin Texts in Machine-Readable Form. We record here our thanks to the Repository and to the original encoders of these texts, R.R. DYER and S.V.F. WAITE, respectively. On the *Culex*, the following recent discussions : A.A. BARRETT, "The Authorship of the *Culex* : an Evaluation of the Evidence," *Latomus* 29 (1970) 348-362; D. GÜNTZSCHEL, *Beiträge zur Datierung des Culex* (Orbis Antiquus 27 : Münster, 1972) esp. pp. 34-43; D.O. ROSS, Jr. "The *Culex* and *Moretum* as Post-Augustan Literary Parodies," *HSCP* 79 (1975) 235-263.

(6)   The general discussion of these matters in L.P. WILKINSON, *Golden Latin Artistry* (Cambridge, 1963) seems to me to be particularly sane

and balanced. For a recent discussion see A.W.H. Adkins, "Lucretius 1.136-139 and the Problems of Writing *Versus Latini*," *Phoenix* 31 (1977) 145-158.

(7)   The presence or absence of initial stress in the fourth foot has received a great deal of attention. It is the central feature noted in W.F.J. Knight, *Accentual Symmetry in Vergil* (Oxford, 1939). See my "Vergil and the Computer : Fourth Foot Texture in Aeneid I," *RELO* 1967 (n° 1) 1-16. Data for the first four feet have been published recently by E. Frank, "The Ictus in the Vergilian and Silver Epic Hexameter," *Istituto Lombardo (Rend. Lett.)* 104 (1970) 327-331.

(8)   The point needs amplification. Suppose, for example that the primary associations were between contiguous pairs, Feet 1 and 2 and Feet 2 and 3; we should not be surprised to find a weaker and more diffuse secondary association persisting for Feet 1 and 3. In Figure 8, however, it is seen that the *Tb* scores for Feet 1 and 3 exceed in amplitude those for either Feet 1 and 2 or for Feet 2 and 3 in seven out of nine cases. (The exceptions are *Aen4* and *Aen12*.) We conclude that the association has a validity of its own apart from that existing between the contiguous feet.

(9)   Some additional observations : for initial stress or its absence in the first three feet, the strongest association (among those noted) is with metrical shape within the same foot. The second strongest association is with initial stress in an adjacent foot. In the fourth foot, however,

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initial stress has its strongest association with the metrical shape of the third foot; its second strongest with initial stress in the third foot. (*Arg1* reverses these.) The above compounds the puzzle. The case of *Aen4* is an extreme example : in the 411 lines with *xxSx* there is no association whatever between initial stress in the third and fourth feet (Tb = 0.01). In the 294 lines with *xxDx*, the association is very strong (Tb = -0.22). This is all quite startling, but we still do not know why there is so little association between metrical shape and initial stress in the fourth foot. We speculate : the poet is constrained to devise a fifth foot dactyl with initial stress. There is also a strong demand for caesura in the third foot and an increasing avoidance of simultaneous initial stress in the third and fourth feet. Given all these claims, it is perhaps not surprising that a normal association of metrical shape and initial stress does not develop in the fourth foot.

10)   These words are deliberately guarded. We cannot tell whether the sixth foot was sensed as a spondee or as a dactyl. We can only guess that a tendency toward uniformity at the end of the line and the admissibility of spondees in the sixth foot argue for some sort of assimilation of the trochaic feet into the genus of the spondee.

11)   Cases of *xllx* and *xxll* are so few in *Cul, Met12, BC1, BC10,* and *Arg1* that it is not possible to report a proper *chi squared* score for the association of metrical shapes in lines of these sorts.

12)   I wish to express my gratitude to the American Council of Learned

Societies and to Oberlin College for generous financial support. The people who run the computers at Oberlin College and Oxford University (especially Susan Hockey) have been gracious and helpful. Finally, I must thank the President and Fellows of Wolfson College, Oxford, for their hospitality.

FIGURE 1

Lucretius, *De Rerum Natura 3 (DRN3)*
Dactyls (D) and spondees (S) in the first four feet.

Four dactyls

DDDD	29

Three dactyls

DDDS	86
DDSD	59
DSDD	39
SDDD	14

Two dactyls

DDSS	189
DSDS	106
DSSD	87
SDDS	47
SDSD	44
SSDD	7

One dactyl

DSSS	221
SDSS	87
SSDS	26
SSSD	15

No dactyls

SSSS	35
Total	1091

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FIGURE 2

DRN3 : Feet 1 and 2. Metrical shape. Actual and (expected) values.

	xSxx	*xDxx*	Totals
Sxxx	83 (135)	192 (140)	275
Dxxx	453 (401)	363 (415)	816
Totals	536	555	1091

X^2 = 51.81
Significance = 0.00000
Tb = -0.22

Summary	*Number*	*Percentage*
SSxx	83	7.6
SDxx	192	17.6
DSxx	453	41.5
DDxx	363	33.3
Total	1091	100.0

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FIGURE 3

DRN3 : Feet 2 and 3. Metrical shape. Actual and (expected) values.

	xxSx	*xxDx*	Totals
xSxx	358 (362)	178 (174)	536
xDxx	379 (375)	176 (180)	555
Totals	737	354	1091

X^2 = 0.21
Significance = 0.64308
Tb = -0.016

Summary	*Number*	*Percentage*
xSSx	358	32.8
xSDx	178	16.3
xDSx	379	34.7
xDDx	176	16.1
Total	1091	99.9

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FIGURE 4

DRN3 : Feet 1 and 3, 1 and 4, 2 and 4, 3 and 4. Metrical shape.

	Number	(Expected)	Percentage		
SxSx	181	(186)	16.6		
SxDx	94	(89)	8.6		
DxSx	556	(551)	51.0		
DxDx	260	(265)	23.8		
				x^2	0.40
				Signif.	0.52
				Tb	-0.02
SxxS	195	(201)	17.9		
SxxD	80	(74)	7.3		
DxxS	602	(596)	55.2		
DxxD	412	(220)	19.6		
				x^2	0.72
				Signif.	0.40
				Tb	-0.03
xSxS	388	(392)	35.6		
xSxD	148	(144)	13.6		
xDxS	409	(405)	37.5		
xDxD	146	(150)	13.4		
				x^2	0.17
				Signif.	0.68
				Tb	-0.01
xxSS	532	(538)	48.8		
xxSD	205	(199)	18.8		
xxDS	265	(259)	24.3		
xxDD	89	(95)	8.2		
				x^2	0.74
				Signif.	0.39
				Tb	-0.03

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FIGURE 5

Corpus : Metrical shape of Feet 1-4 in percentages

	DRN3	Cul	Ecl	Aen4	Aen12	Met12	BC1	BC10	Arg1
Dxxx	74.8	67.9	65.1	61.6	57.7	81.4	65.2	64.6	79.7
Sxxx	25.2	32.1	34.9	38.4	42.3	18.6	34.8	35.4	20.3
xDxx	50.9	55.6	51.7	50.2	43.6	52.1	43.9	45.6	45.7
xSxx	49.1	44.4	48.3	49.8	56.4	47.9	56.1	54.4	54.3
xxDx	32.4	38.4	40.0	41.7	42.1	41.4	42.2	44.0	54.7
xxSx	67.6	61.6	60.0	58.3	57.9	58.6	57.8	56.0	45.3
xxxD	26.9	31.9	38.6	25.8	22.9	41.9	25.1	25.7	34.0
xxxS	73.1	68.1	61.4	74.2	77.1	58.1	74.9	74.3	66.0

FIGURE 6

Corpus : Metrical Shape : three Combinations in percentages

	DRN3	*Cul*	*Ecl*	*Aen4*	*Aen12*	*Met12*	*BC1*	*BC10*	*Arg1*
SSxx	7.6·	11.4	14.8	16.3	20.0	7.3	13.8	16.4	8.0
SDxx	17.6	20.8	20.1	22.1	22.4	11.3	21.0	19.0	12.2
DSxx	41.5	33.1	33.5	33.5	36.4	40.6	42.3	38.0	46.3
DDxx	33.3	34.8	31.6	28.1	21.2	40.8	22.9	26.6	33.5
X^2	51.81	6.05	5.85	9.05	23.73	3.86	39.67	7.23	18.21
Signif.	0.00	0.01	0.02	0.00	0.00	0.05	0.00	0.01	0.00
Tb	-0.22	-0.13	-0.09	-0.12	-0.16	-0.08	-0.24	-0.12	-0.15
xSSx	32.8	27.5	26.5	28.5	31.3	26.0	28.1	25.0	20.0
xSDx	16.3	16.9	21.8	21.3	25.1	22.0	28.0	29.4	34.3
xDSx	34.7	34.1	33.5	29.8	26.6	32.6	29.7	31.0	25.3
xDDx	16.1	21.5	18.2	20.4	17.0	19.4	14.2	14.6	20.4
X^2	0.21	0.00	8.12	0.23	2.65	4.36	20.70	25.89	28.46
Signif.	0.64	0.97	0.00	0.63	0.10	0.04	0.00	0.00	0.00
Tb	-0.02	-0.01	-0.10	-0.02	-0.05	-0.09	-0.18	-0.22	-0.19
xxSS	48.8	39.1	36.1	42.3	44.1	33.0	40.9	40.3	25.4
xxSD	18.8	22.5	23.9	16.0	13.8	25.6	17.0	15.7	19.9
xxDS	24.3	29.0	25.3	31.9	33.0	25.2	34.1	33.9	40.5
xxDD	8.2	9.4	14.7	9.8	9.1	16.2	8.1	10.0	14.1
X^2	0.74	5.89	0.64	1.25	0.46	1.10	8.57	1.64	29.68
Signif.	0.39	0.02	0.42	0.26	0.50	0.29	0.00	0.20	0.00
Tb	-0.03	-0.12	-0.03	-0.05	-0.02	-0.05	-0.11	-0.06	-0.19

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FIGURE 7

Corpus : Initial stress in Feet 1-4 in percentages

	DRN3	Cul	Ecl	Aen4	Aen12	Met12	BC1	BC 10	Arg1
Oxxx	21.8	24.4	18.0	29.8	33.8	20.7	29.1	27.9	23.8
Ixxx	78.2	75.6	82.0	70.2	66.2	79.3	70.9	72.1	76.2
xOxx	55.9	67.4	58.7	61.4	68.2	63.1	67.5	66.8	67.7
xIxx	44.1	32.6	41.3	38.6	31.8	36.9	32.5	33.2	32.3
xxOx	77.2	86.0	80.2	76.3	70.8	86.5	79.0	76.6	69.8
xxIx	22.8	14.0	19.8	23.7	29.2	13.5	21.0	23.4	30.2
xxxO	50.6	61.6	60.5	59.3	62.2	53.3	57.7	62.4	71.4
xxxI	49.4	38.4	39.5	40.7	37.8	46.7	42.3	37.6	28.6

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FIGURE 8

Corpus : Initial Stress : Four Combinations in percentages

	DRN3	Cul	Ecl	Aen4	Aen12	Met12	BC1	BC10	Arg1
OOxx	14.7	16.7	14.6	20.3	26.1	13.4	21.0	18.4	17.9
Olxx	7.1	7.7	3.4	9.5	7.8	7.3	8.1	9.5	5.9
lOxx	41.2	50.7	44.1	41.1	42.1	49.7	46.5	48.4	49.8
llxx	36.9	24.9	38.0	29.1	24.1	29.6	24.3	23.7	26.4
x^2	15.23	0.01	36.90	5.23	16.94	0.10	2.45	0.02	6.42
Signif.	0.00	0.92	0.00	0.02	0.00	0.76	0.12	0.89	0.01
Tb	0.12	0.01	0.21	0.09	0.14	0.02	0.06	-0.01	0.09
OxOx	14.9	19.3	12.2	21.6	20.9	15.9	19.1	18.2	13.3
Oxlx	6.9	5.1	5.8	8.2	12.9	4.8	10.0	9.7	10.5
lxOx	62.2	66.7	68.1	54.8	49.9	70.5	59.9	58.4	56.5
lxlx	15.9	8.9	14.0	15.5	16.3	8.8	11.0	13.7	19.7
x^2	12.43	4.38	16.83	2.26	18.40	11.75	29.17	14.23	23.48
Signif.	0.00	0.04	0.00	0.13	0.00	0.00	0.00	0.00	0.00
Tb	-0.11	-0.11	-0.15	-0.06	-0.14	-0.14	-0.21	-0.17	-0.17
xOOx	42.3	56.0	44.7	42.4	43.7	51.9	48.1	44.5	38.8
xOlx	13.7	11.4	14.0	19.0	24.5	11.1	19.4	22.3	29.0
xlOx	34.9	30.0	35.5	33.9	27.1	34.6	30.9	32.1	31.1
xllx	9.2	2.7	5.8	4.7	4.7	2.4	1.6	1.1	1.2
x^2	1.82	5.01	11.64	31.68	43.26	14.77	50.39	59.59	133.08
Signif.	0.18	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tb	-0.04	-0.12	-0.12	-0.22	-0.22	-0.16	-0.27	-0.33	-0.40
xxOO	36.7	49.0	44.5	41.8	40.2	41.9	39.0	40.3	41.9
xxOl	40.5	37.0	35.8	34.5	30.6	44.6	40.0	36.3	27.9
xxlO	13.9	12.6	16.0	17.4	22.0	11.5	18.7	22.1	29.4
xxll	8.9	1.4	3.7	6.2	7.2	2.1	2.3	1.3	0.7
x^2	13.55	21.09	35.28	17.93	27.42	37.41	71.99	71.68	122.05
Signif.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tb	-0.11	-0.23	-0.21	-0.16	-0.17	-0.25	-0.33	-0.37	-0.38

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FIGURE 9

DRN3 : Foot 1. Crosstabulation of metrical shape and initial stress.
Actual and (expected) values.

	Oxxx	*Ixxx*	Totals
Sxxx	100 (60)	175 (215)	275
Dxxx	138 (178)	678 (638)	816
Totals	238	853	1091

Summary in percentages

Foot 1		Foot 2	
$S^O xxx$	9.2	$xS^O xx$	33.3
$S^1 xxx$	16.0	$xS^1 xx$	15.9
$D^O xxx$	12.6	$xD^O xx$	22.6
$D^1 xxx$	62.1	$xD^1 xx$	28.2
$X^2 = 44.50$		$X^2 = 58.70$	
Signif. = 0.00		Signif. = 0.00	
Tb = 0.20		Tb = 0.23	

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FIGURE 10

Corpus : Metrical form and initial stress in each foot (Percentages)

	DRN3	Cul	Ecl	Aen4	Aen12	Met12	BC1	BC10	Arg1
$S^O xxx$	9.2	13.5	11.2	16.7	21.7	9.6	16.5	16.1	9.4
$S^1 xxx$	16.0	18.6	23.7	21.7	20.6	9.1	18.3	19.3	10.8
$D^O xxx$	12.6	10.9	6.7	13.0	12.1	11.1	12.6	11.9	14.4
$D^1 xxx$	62.1	57.0	58.3	48.5	45.6	70.2	52.6	52.7	65.4
X^2	44.50	31.92	58.85	38.76	94.71	79.65	58.79	44.06	59.84
Signif.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tb	0.21	0.28	0.27	0.24	0.32	0.36	0.30	0.29	0.27
$xS^O xx$	33.3	35.7	34.0	37.7	44.3	35.8	44.8	46.2	42.3
$xS^1 xx$	15.9	8.7	14.3	12.1	12.1	12.1	11.3	8.2	12.0
$xD^O xx$	22.6	31.6	24.7	23.7	23.8	27.2	22.8	20.6	25.4
$xD^1 xx$	28.2	23.9	27.0	26.5	19.7	24.8	21.2	25.0	20.3
X^2	58.70	24.58	42.50	59.67	60.46	32.97	59.63	94.81	46.51
Signif.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tb	0.23	0.25	0.23	0.29	0.25	0.23	0.30	0.42	0.24
$xxS^O x$	56.2	59.9	55.5	50.1	47.8	55.9	54.6	54.6	42.5
$xxS^1 x$	11.4	1.7	4.5	8.2	10.1	2.7	3.2	1.5	2.8
$xxD^O x$	21.0	26.1	24.7	26.2	23.0	30.6	24.3	22.1	27.3
$xxD^1 x$	11.5	12.3	15.3	15.5	19.1	10.8	17.8	21.9	27.3
X^2	45.35	67.52	117.43	48.73	86.44	58.54	134.75	165.30	189.30
Signif.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tb	0.21	0.41	0.38	0.27	0.30	0.31	0.45	0.55	0.48
$xxxS^O$	38.0	42.0	40.4	45.8	48.1	31.7	44.8	47.6	50.4
$xxxS^1$	35.0	26.1	21.1	28.4	29.0	26.4	30.1	26.6	15.5
$xxxD^O$	12.6	19.6	20.1	13.5	14.1	21.7	12.9	14.8	21.0
$xxxD^1$	14.4	12.3	18.4	12.3	8.8	20.1	12.2	10.9	13.1
X^2	2.36	0.00	14.43	4.73	0.03	0.38	3.35	1.72	19.82
Signif.	0.12	0.97	0.00	0.03	0.87	0.54	0.07	0.19	0.00
Tb	0.05	0.00	0.13	0.09	0.01	0.03	0.07	0.06	0.16

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FIGURE 11

DRN3 : Feet 1 and 2. Metrical shape and initial stress combined.
Actual and (expected) values. /Cell-contribution toward X^2./

	xS^Oxx	xS^1xx	xD^Oxx	xD^1xx	*Totals*
S^Oxxx	23 (33) /3.17/	6 (16) /6.13/	29 (23) /1.79/	42 (28) /6.72/	100
S^1xxx	32 (58) /11.81/	22 (28) /1.19/	38 (40) /0.07/	83 (49) /22.85/	175
D^Oxxx	63 (46) /6.36/	8 (22) /8.81/	45 (31) /6.06/	22 (39) /7.38/	138
D^1xxx	245 (226) /1.67/	137 (107) /8.09/	135 (153) /2.23/	161 (191) /4.83/	678
Totals	363	173	247	308	1091

X^2 = 99.14 with 9 degrees of freedom.

Significance = 0.00

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FIGURE 12

DRN3 : Feet 1 and 2. Metrical shape in the 160 lines with *OOxx,*
i.e., 14.7 % of the work.

	xSxx	*xDxx*	*Totals*
Sxxx	23 (28)	29 (24)	52
Dxxx	63 (58)	45 (50)	108
Totals	86	74	160

Summary for all combinations of initial stress.

	OOxx		*IOxx*		*OIxx*		*IIxx*	
No. of lines	160		450		78		403	
% of *DRN3*	14.7		41.2		7.1		36.9	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
SSxx	23	14.4	32	7.1	6	7.7	22	5.5
SDxx	29	18.1	38	8.4	42	53.8	83	20.6
DSxx	63	39.4	245	54.4	8	10.3	137	34.0
DDxx	45	28.1	135	30.0	22	28.2	161	40.0
χ^2	2.27		8.02		1.65		19.31	
Significance	0.13		0.00		0.20		0.00	
Tb	- 0.13		- 0.14		- 0.18		- 0.22	

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FIGURE 13

Corpus : Feet 1 & 2 : Metrical shape within each combination of initial stress (Percentages)

	DRN3	Cul	Ecl	Aen4	Aen12	Met12	BC1	BC10	Arg1
OOxx	14.7	16.7	14.5	20.3	26.1	13.4	21.0	18.4	17.9
SSxx	14.4	27.5	31.4	39.2	33.1	20.2	29.7	40.6	19.1
SDxx	18.1	27.5	31.4	17.5	28.2	20.2	18.6	12.9	10.5
DSxx	39.4	21.7	25.6	23.1	28.2	35.7	33.1	30.7	42.1
DDxx	28.1	23.2	11.6	20.3	10.5	23.8	18.6	15.8	28.3
x^2	2.27	0.01	3.38	3.14	8.14	0.47	0.02	0.78	0.12
Signif.	0.13	0.91	0.07	0.08	0.00	0.50	0.88	0.38	0.72
Tb	-0.13	0.02	-0.18	0.16	-0.19	-0.10	-0.03	0.11	0.04
IOxx	41.2	50.7	44.1	41.1	42.1	49.7	46.5	48.4	49.8
SSxx	7.1	11.0	16.4	15.5	18.0	7.1	13.4	17.7	7.8
SDxx	8.4	11.4	12.3	14.8	11.5	5.4	10.0	5.7	5.0
DSxx	54.5	43.3	41.8	45.5	49.4	50.0	54.5	50.6	55.1
DDxx	30.0	34.3	29.5	24.1	21.2	37.5	22.1	26.0	32.2
x^2	8.02	0.45	0.02	4.62	2.63	0.01	4.41	1.68	0.02
Signif.	0.00	0.50	0.89	0.03	0.10	0.93	0.04	0.20	0.89
Tb	-0.14	-0.06	-0.01	-0.13	-0.09	-0.00	-0.13	0.09	-0.01
OIxx	7.1	7.7	3.4	9.5	7.8	7.3	8.1	9.5	5.9
SSxx	7.7	6.3	3.6	11.9	20.3	10.9	8.9	1.9	6.0
SDxx	53.8	50.0	57.1	43.3	54.1	45.7	69.6	63.5	64.0
DSxx	10.3	9.4	3.6	6.0	12.2	6.5	7.1	5.8	12.0
DDxx	28.2	34.4	35.7	38.8	13.5	37.0	14.3	28.8	18.0
x^2	1.65	0.09	0.18	0.31	1.77	0.00	1.94	1.49	5.06
Signif.	0.20	0.76	0.67	0.58	0.18	0.99	0.16	-0.22	0.02
Tb	-0.18	-0.14	-0.06	0.10	-0.19	0.06	-0.25	-0.25	-0.37
IIxx	36.9	24.9	38.0	29.1	24.1	29.6	24.3	23.7	26.4
SSxx	5.5	2.9	7.6	2.9	9.2	1.1	2.4	0.8	1.3
SDxx	20.6	26.2	21.6	8.8	14.9	8.6	28.0	33.1	15.6
DSxx	34.0	27.2	29.5	32.7	30.6	35.5	38.7	30.8	40.2
DDxx	40.0	43.7	41.3	35.6	35.4	54.8	31.0	35.4	42.9
x^2	19.31	6.83	6.15	27.22	7.32	4.42	31.47	24.37	19.67
Signif.	0.00	0.01	0.01	0.00	0.01	0.04	0.00	0.00	0.00
Tb	-0.22	-0.28	-0.15	-0.37	-0.19	0.17	-0.44	-0.45	-0.31

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APPENDIX

The following list of *Tb* scores is based upon the data compiled by
G.E. Duckworth and published in *TAPA* 95 (1964) 58; 96 (1965) 92; 97
(1966) 110-113; 98 (1967) 146-150. The order is that found in Duckworth,
but some items have been omitted and scores have been inserted for Lucan
1 and 10 and for Valerius Flaccus 1.

In general, *Tb* scores less than 0.10 do not justify rejecting the null hypothe-
sis of statistical independence. Further, the individual *Eclogues* are too short
for reliable inferences. Nonetheless, it is noteworthy and descriptively valid
that the only significant positive *Tb* score on the list is for the combination
of third and fourth feet in *Eclogue* 4. This poem contains more instances of
xxSS and *xxDD* than one would expect. Otherwise all significant scores on
the list are negative, indicating a general tendency toward the alternation of
metrical shape.

Significant scores for the first and second feet are frequent throughout the
list. For the combination of the second and third feet, a dramatic change
occurs with the *Aetna*. Up to that point on the list, significant scores are
a rarity; thereafter, they form the vast majority. The combination of third
and fourth feet generally exhibits insignificant scores with some glaring ex-
ceptions. For the rest, the list must speak for itself.

Note on computation : Given a 2 x 2 table with cells labelled as follows :

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$$\begin{array}{cc} a & b \\ c & d \end{array}$$

$$Tb = \frac{ad - bc}{\sqrt{(a + b)\ (c + d)\ (a + c)\ (b + d)}}$$

			Feet 1 and 2	Feet 2 and 3	Feet 3 and 4
Vergil, *Eclogues*		1	-0.05	-0.24	-0.06
"	"	2	0.03	-0.19	-0.02
"	"	3	0.04	0.04	-0.02
"	"	4	-0.19	-0.22	0.17
"	"	5	-0.24	-0.15	-0.06
"	"	6	-0.03	-0.03	0.05
"	"	7	-0.07	-0.09	-0.01
"	"	8	0.04	-0.06	0.03
"	"	9	-0.04	-0.02	-0.10
"	"	10	-0.34	-0.02	-0.15
"	"	(entire)	-0.09	-0.10	-0.03
Vergil, *Georgics*		1	-0.20	-0.04	-0.06
"	"	2	-0.19	-0.11	-0.02
"	"	3	-0.07	-0.05	-0.08
"	"	4	-0.18	-0.13	-0.02
"	"	(entire)	-0.16	-0.08	-0.05
Vergil, *Aeneid*		1	-0.12	-0.10	-0.04
"	"	2	-0.13	-0.06	-0.03
"	"	3	-0.08	-0.04	-0.03
"	"	4	-0.12	-0.02	-0.05
"	"	5	-0.07	-0.04	-0.05
"	"	6	-0.15	-0.11	-0.02
"	"	7	-0.08	-0.13	-0.07
"	"	8	-0.08	-0.07	-0.04
"	"	9	-0.10	-0.04	0.01
"	"	10	-0.15	-0.09	-0.03
"	"	11	-0.06	-0.09	-0.04
"	"	12	-0.16	-0.05	-0.02

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	Feet 1 and 2	Feet 2 and 3	Feet 3 and 4
Vergil, *Aeneid* (entire)	-0.11	-0.07	-0.04
Horace, *Satires*, Bk. 1	-0.11	-0.05	-0.04
" *Epistles,* Bks. 1, 2	-0.17	-0.10	-0.07
" *Ars Poetica*	-0.15	-0.07	-0.08
Ennius, *Fragments*	0.03	0.08	0.02
Lucilius, *Fragments*	-0.19	-0.10	0.02
Cicero, all hexameters	-0.06	0.00	-0.01
Lucretius 1	-0.12	0.05	-0.04
" 2	-0.15	-0.05	0.02
" 3	-0.22	-0.02	-0.03
" 4	-0.18	-0.01	-0.03
" 5	-0.18	0.01	-0.03
" 6	-0.14	-0.01	-0.02
" (entire)	-0.16	0.00	-0.02
Catullus 64	-0.26	-0.14	0.02
Ovid, *Metamorphoses* 1	-0.23	-0.05	-0.06
" " 2	-0.17	-0.08	-0.09
" " 3	-0.15	-0.08	-0.08
" " 7	-0.22	-0.08	-0.10
" " 12	-0.08	-0.09	-0.05
" " (entire)	-0.17	-0.08	-0.07
Culex	-0.13	-0.01	-0.12
Ciris	-0.05	0.01	-0.11
Moretum	-0.24	0.00	0.03
Aetna	-0.23	-0.19	-0.06
Grattius, *Cynegetica*	-0.18	-0.18	-0.07
Germanicus Caesar (entire)	-0.12	-0.12	0.02
Manilius, *Astron.* (entire)	-0.19	-0.10	-0.02

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	Feet 1 and 2	Feet 2 and 3	Feet 3 and 4
Columella 10	-0.22	-0.15	-0.11
Nemesianus, *Cynegetica*	-0.16	-0.16	-0.02
Calpurnius Siculus, *Eclogues*	-0.18	-0.16	-0.15
Persius (entire)	-0.21	-0.13	-0.03
Juvenal (entire)	-0.19	-0.13	-0.07
Lucan 1	-0.24	-0.18	-0.11
" 10	-0.12	-0.22	-0.06
" (entire)	-0.20	-0.19	-0.10
Petronius	-0.14	-0.12	-0.07
Valerius Flaccus 1	-0.15	-0.19	-0.19
" " (entire)	-0.20	-0.20	-0.20
Statius, *Thebais*	-0.14	-0.14	-0.07
" *Achilleis*	-0.17	-0.14	-0.13
" *Silvae*	-0.15	-0.18	-0.12
Ilias Latina	-0.09	-0.07	-0.02
Silius Italicus (entire)	-0.11	-0.10	-0.04
Avienus	-0.20	-0.02	-0.05
Ausonius, *Mosella*	-0.07	-0.05	-0.09
Claudian 1	-0.31	-0.29	-0.12
Sidonius	-0.13	-0.19	-0.04
Corippus	-0.09	-0.26	-0.06
Juvencus	-0.07	-0.10	-0.03
Proba	-0.19	-0.09	-0.06
Marius Victor	-0.11	-0.13	-0.02
Prudentius	-0.18	-0.17	-0.04
Paulinus Nola	-0.13	-0.12	-0.06
Dracontius	-0.02	-0.25	-0.06
Cyprian	-0.12	-0.26	0.01
Arator	-0.02	-0.37	-0.22

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