# STYLOCHRONOMETRY WITH SUBSTRINGS
# Or: A Poet Young and Old

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"Laughter not time destroyed my voice
And put that crack in it"
-- *A Man Young and Old*, W.B. Yeats (1926).

**Abstract**

Assigning a date to a text is an important task in stylometry. Most previous researchers, however, have worked on intractable problems, where a true chronology will never be known with certainty, such as the works of Plato, Shakespeare or Marlowe. It is argued here that stylochronometric methods should be extensively tested on unproblematic texts before being used in disputed cases. As part of such testing, the present study applies a novel technique, Monte-Carlo Feature-Finding (Forsyth, 1997), to the verse of W.B. Yeats, where the dating is relatively well documented. Yeats insisted that his language changed as he grew older, and most readers would concur; yet scholars have not reached agreement on the nature of this linguistic change (Jaynes, 1980).

A quasi-random search algorithm was used to find marker substrings in 142 poems of Yeats. To test their distinctiveness, four trials were performed: (1) assignment of 10 poems absent from the training sample to their correct period; (2) detecting differences in two poems written by Yeats in his twenties and revised when he was sixty; (3) constructing a regression formula; (4) classifying two prose extracts written 46 years apart.

Assigning short poems (median length 114 words) to their correct chronological period is a non-trivial task. Nevertheless, counting of distinctive substrings gave the right assignment in 9 out of 10 unseen cases. Moreover, these substring frequencies were sensitive enough to detect authorial revision in two early poems revised by Yeats many years after he originally wrote them, and robust enough to classify a pair of short prose extracts correctly; as well as accounting for 71% of the variance when used in a regression to predict the year in which 13 poems, absent from the training sample, were composed.

These results suggest that short substrings found by a Monte-Carlo process warrant further investigation as stylistic indicators.

**Keywords:** Monte-Carlo Methods, Stylistics, Stylochronometry, Yeats.

## 1. Introduction

Methods of assigning dates to texts have long been of interest to literary scholars. In the words of Graham Martin:

> "in one way or another, the study of even a single poet moves necessarily towards a process of comparison and contrast between poem and poem and then between poet and poet, and because poets write and publish at particular moments in time, that means, at some point, chronology." (Martin, 1975, p. 5)

Apart from authorship attribution, date assignment (stylochronometry) is the most commonly reported task in the stylometric literature. Yardi (1946), Brainerd (1980), Ule (1982), Foster (1989) and Temple (1996) are just some of the researchers who have addressed this problem.

A variety of different linguistic indicators have been used for this task, often based on prosody or scansion (such as the proportion of `feminine' line endings), and many such indicators are generally used in combination, as part of a multivariate analysis. Nevertheless, Foster reported good results with a single variable:

> "the frequency of *most* (excluding its use as a substantive) is one of the best indicators for dating Shakespeare's work, and certainly one of the simplest." (Foster, 1989, p. 109)

Methodologically, however, the five studies cited above suffer from a common problem: they deal with cases where a true chronology will never be known with certainty -- the plays of Shakespeare, the writings of Christopher Marlowe and the Platonic corpus. The present study, in contrast, follows the practice of Frischer (1991) in his attempt to assign a date to Horace's *Ars Poetica*. Frischer first conducted a systematic search through the poet's securely dated works for what he termed chronometers -- habits that change regularly over time -- and then applied these chronometers (such as the usage rates of `ad' or `sed') to estimate the unknown date of the *Ars Poetica*. Statistical methods were used to filter out from the potential indicators those whose pattern of temporal variation could be explained as chance variation.

The present investigation follows this general approach, and thus differs from much previous research in this field, by concentrating on a test case -- the verse of William Butler Yeats -- where the dating is comparatively well attested. Additionally, it extends Frisher's paradigm by further automating the search for potential chronometers. Specifically, it applies a novel technique called Monte-Carlo Feature-Finding (Forsyth & Holmes, 1996) to test its suitability in this area. This method seeks short substrings and accordingly is not limited to discovering **words** as chronometers. It can also find subwords (e.g. affixes such as `ing' or `tion') as well as collocations (such as `in the' or `ed by').

Dating Yeats makes an interesting initial test because over the course of a long poetic career his style changed noticeably; yet scholars do not agree on the nature of that change. In this context, it is pertinent to quote Jaynes (1980), who also studied the

evolution of Yeats's poetic style:

> "Yeats's syntactic style is quite stable over his career." (Jaynes, 1980, p. 13)

as well as Martindale (1990), who investigated historical trends in poetic language in both English and French over several centuries:

> "the content of most poets' verse does not change massively across the course of a lifetime".

However, Yeats himself firmly believed that his syntax and diction evolved as he grew older (a view shared by many of his readers) as the following quotations testify.

> "My own verse has more and more adopted -- seemingly without any will of mine -- the syntax and vocabulary of common personal speech." (Yeats, 1926; in Jaynes, 1980, p. 11)

> "It was a long time before I had made a language to my liking". (Yeats, 1937; in Jeffares, 1964, p. 265)

## 2. Method

The main aim of the present study was to find out whether an automated method of characterizing textual differences which has shown promise in other areas (Forsyth, 1997) could be used to analyze the development in a particular poet's use of language. This method, Monte-Carlo Feature-Finding, is simply a random search for substrings that exist in the training data. It is implemented by a program called TEFF (Text Extending Feature Finder). This finds markers merely by searching through a given set of training texts.

TEFF randomly picks many substrings (4096 in the experiment reported here) from the combined training text. The length of each substring is also a random number from 1 to 8. All distinct substrings thus found are saved and then ranked according to their distinctiveness, i.e. according to a measure of their differential rate of occurrence in the different text categories for the problem concerned. Chi-squared is used to measure distinctiveness:

$$\sum_j \frac{(O_j - E_j)^2}{E_j}$$

where $O_j$ is the observed frequency in a given text category and $E_j$ is the expected frequency, assuming an equal rate of occurrence in each category.

Earlier trials of Monte-Carlo Feature-Finding (Forsyth, 1995) indicated that the basic procedure, as described above, tends to generate substrings that are fragmented at what seem linguistically inappropriate boundary points, even when they prove effective as discriminators. This weakness has since been rectified, by a `string stretching' procedure. For technical details see Forsyth & Holmes (1996) or Forsyth (1997).

Another improvement to the basic TEFF procedure was employed in the experiment reported here. The texts were divided into blocks of approximately 1030 characters (in fact at the first white-space character after 1024 bytes). Then substrings were counted within blocks and the square-root of each within-block count summed to give an adjusted total frequency for each substring. The practical effect of this adjustment is to downgrade the importance of indicators that occur in localized bursts relative to those whose usage is pervasive throughout a text. (A fuller explanation is given in Forsyth (1997).)

## 3. Materials

A random sample of 142 poems by W.B. Yeats was used as training data. This sample was divided into two portions:

"Younger Yeats" (YY), 72 poems, 18,360 words;
"Older Yeats" (OY), 70 poems, 18,668 words.

The dividing date was 1915. Thus the YY sample was written in 1914 or before and the OY sample from 1916 onwards[1].

The TEFF program was used to find substrings which distinguished these two classes. Then the efficacy of these substrings as distinctive markers was tested on three types of unseen material: (1) 10 other poems, absent from the training sample; (2) two early poems that Yeats later heavily revised; and (3) two prose extracts. Details of these tests are given in the next section.

## 4. Results

The following listing (Table 1) shows the 65 most distinctive substrings found by the TEFF program when given samples of poetry written by William Butler Yeats before 1915 (`Younger Yeats') or after 1915 (`Older Yeats').

**Table 1 -- Substrings Found by TEFF.**

```
TEFF output;  date: 10/25/97 21:27:58

Rank        Substring  Chi-score
1               `what  35.2977123    30.  100.
2               ` can  34.5481048    21.  82.
3              ` can   32.1377981    13.  66.
-4              `hat   29.8459659    132.  245.
5               `hat   28.7157873    126.  235.
6               ` whi  25.8148745    67.  21.
7              `s, an  25.3604502    63.  19.
8               ` sea  23.8708713    52.  13.
9              ` that  23.0786873    114.  206.
10               `?    22.3848552    30.  83.
11             ` with  22.242135    139.  74.
12              ` int  21.9169178    12.  51.
13              `. ii  21.4710501    0.  23.
14            ` stars  20.9510074    26.  2.
```

[1] This division is not haphazard: 1914 is the date of the outbreak of World War I and 1916 the date of the Irish Easter Rising, both events that profoundly affected Yeats's beliefs about what poetry should aim to achieve.

```
15             ` that   20.8584369    114.  200.
16               `ith   20.3048191    134.  72.
17              `s of   20.0069369    105.  52.
18             `e that  19.4328782    18.  58.
19             `though  18.6119958    30.  77.
20               ` you  18.4021636    120.  65.
21                `ou   18.338578    70.  29.
22           `e that    17.6827819    18.  56.
-23               `at   17.6339928    223.  332.
24             `, and   17.5216778    173.  108.
-25               `ith  17.5057402    143.  84.
-26              ` tha  17.4767001    127.  209.
27              `ping   17.3800959    34.  7.
28              ` you   17.1449342    68.  29.
29              `your   16.933698    52.  19.
30                ` we  16.8084892    141.  83.
-31              `, an   16.6399743    176.  112.
32             ` your   16.5048223    49.  17.
33               `woo   16.2479445    32.  7.
34                `ck   15.9644919    51.  103.
35               `low   15.935057    70.  32.
36               `wed   15.7755436    23.  3.
37             ` the w  15.7503404    103.  56.
38             `w the   15.5959647    31.  7.
39             `murmur  15.5603536    21.  2.
40              ` of o  15.5309625    27.  5.
41               ` dee  15.3281468    28.  5.
42                ` wa  15.2033782    141.  86.
43                `ec   15.0040229    42.  89.
44              `its    14.9342107    16.  49.
45                `io   14.8929466    46.  94.
46              `hat c  14.7247314    11.  39.
47                ` fl  14.6750908    85.  44.
48                `ic   14.641333    54.  105.
49               `. an  14.4836672    39.  12.
-50              `th    14.3405652    155.  99.
51               `mag   14.2989514    9.  36.
-52                `wa  14.263478    168.  110.
53             `tion    14.2141891    7.  32.
54           `ountain   14.0862749    0.  16.
-55               `s,   13.5564112    160.  105.
-56             `he w   13.4639408    110.  65.
57           ` over th  13.2886104    16.  1.
58             `ering   13.149059    61.  28.
-59               `t    13.1179103    314.  426.
60             `t can   12.8095651    2.  19.
61               `mat   12.8064674    3.  22.
62            `e white  12.5426343    13.  0.
63             `k and   12.519069    2.  19.
64             `ittle   12.4591915    24.  5.
65         `the fenian  12.3657293    13.  0.
```

Roughly speaking, a string is a Younger-Yeats marker if the first of the last 2 frequency counts in the preceeding table is higher than the second; so, for example, `murmur', at rank 39, is a Younger-Yeats marker (n=21 versus n=2).

A minus-sign in front of a rank number indicates a marker which is a proper substring of another higher up in the table, and which will therefore not be saved on file. This removes some of the redundancy from the list, but not all of it. So a further program was written to filter out substrings that duplicate the effect of those higher in the list. This was done by `destructive' counting: in TEFF, substrings are counted independently, but in the post-filtering program they are read in the order output by TEFF (an order of distinctiveness) and processed in that order. As a string is counted,

it is removed from the text block currently being processed. So, for example, if `what' has already been counted, occurrences of `hat' will only be found that are not embedded within `what' (as in `that' or `hatred' but not `whatever'). The result of running this latter program is shown in Table 2.

**Table 2 -- Marker Substrings.**

```
filters.spt  date: 10/25/97 22:07:45
1  C:\BM95\WY.Yx  96547 bytes.
2  C:\BM95\WY.Ox  100322 bytes.
proportion in class 1 = 0.4904112
proportion in class 2 = 0.5095863
Grams kept = 88

Rank        Substring  Chi-score
1               `what  35.1125492    30.  100.
2               ` can  34.3848949    21.  82.
3              `s, an  25.4882859    63.  19.
4               ` whi  25.4359635    67.  21.
5              ` with  22.3028559    139.  74.
6                `?    21.9694592    30.  83.
7               ` sea  21.9076975    49.  13.
8               ` int  21.814545    12.  51.
9               `. ii  21.4093664    0.  23.
10             ` stars  21.0202576    26.  2.
11               `ck  20.7388396    35.  87.
12              ` we  20.6404509    139.  76.
13             `hat   20.6188054    113.  200.
14            `s of   19.2516067    104.  52.
15           `though  18.5468022    30.  77.
16              ` you  18.1662318    115.  62.
17             ` that  17.7369649    3.  27.
18             `ping   16.5610752    33.  7.
19              `woo  16.3187661    32.  7.
20              ` dee  16.2970505    27.  4.
```

It should be noted that these are strings, not words, so item 16 ` you' (a YY marker) would cover words such as `young' `younger' `youth' and `your' as well as the word `you' itself.

The presence of `? ' on this list suggests that this method is potentially capable of detecting some kinds of syntactic or semiotic change as well as changes in vocabulary. However, a question-mark may not consistently signal the same syntactic structure (still less the same kind of speech act) over the course of an author's career; so the interpretation of such a change in preference still requires scrutiny of the texts themselves.

Only the top twenty markers have been shown in Table 2, to save space; and only these will be used in the analysis that follows. Note that the sole element of human judgement involved in choosing these markers was deciding how many to use, 20 being a convenient number.

## 5. Some Marks of Time

As an illustration, Table 3 shows the results of counting the occurrences of eleven Younger-Yeats and nine Older-Yeats marker substrings in a pair of poems written 50 years apart.

**Table 3 -- Frequencies of Substrings in 2 Short Poems.**

| **Marker Substrings:** | **Salley Gardens 1888** [98 words] | **Politics 1938** [80 words] |
|---|---|---|
| Younger-Yeats: | | |
| `s, an` | 0 | 0 |
| ` whi` | 0 | 0 |
| ` with` | 2 | 0 |
| ` sea` | 0 | 0 |
| ` stars` | 0 | 0 |
| ` we` | 1 | 1 |
| `s of` | 0 | 0 |
| ` you` | 2 | 1 |
| `ping ` | 0 | 0 |
| `woo` | 0 | 0 |
| ` dee` | 0 | 0 |
| Total = | 5 | 2 |
| Older-Yeats: | | |
| `what` | 0 | 2 |
| ` can` | 0 | 1 |
| `? ` | 0 | 1 |
| ` int` | 0 | 0 |
| `. ii` | 0 | 0 |
| `ck` | 0 | 0 |
| `hat ` | 0 | 6 |
| `though` | 0 | 1 |
| ` that` | 0 | 4 |
| Total = | 0 | 15 |

This shows a clear preponderance of `younger' markers in the earlier poem and an even clearer preponderance of `older' markers in the later poem. If either of these texts had just been rediscovered, we could with reasonable confidence allocate *Down by the Salley Gardens* to Yeats's early career and *Politics* to his later years.

Perhaps it is worth noting here that stylometers have generally found chronology a trickier subject than authorship attribution (Forsyth, 1995), and that they have very rarely dared to categorize text segments as short as these 2 poems -- a notable exception being Simonton (1990), who analyzed, among other things, word usage in the final couplets of Shakespeare's sonnets, averaging 17.6 words in length.

However, both these poems were present in the training files. Thus Table 3 merely illustrates this method.

*5.1 Unseen Trial*

As a genuine test, 10 more poems were chosen from Yeat's Collected Poems, at random, five written before 1915 and five afterwards -- with the proviso that they were not already present in the training sample. These poems, and their dates of composition, are listed in Table 4, along with counts of the YY and OY substrings found in each.

**Table 4 -- Substring Counts in 10 Unseen Poems.**

| Poem ↓ | Total Count of Younger-Yeats Markers (YY) | Total Count of Older-Yeats Markers (OY) |
|---|---|---|
| A Faery Song (1891) [104 words] | 10 | 1 |
| The Lover Tells of the Rose in His Heart (1892) [114 words] | 10 | 4 |
| The Hosting of the Sidhe (1893) [124 words] | 6 | 2 |
| The Host of the Air (1893) [310 words] | 23 | 4 |
| To Some I Have Talked with by the Fire (1895) [139 words] | 9 | 0 |
| A Woman Young and Old -- Parting (1926) [79 words] | 4 | 6 |
| In Memory of Eva Gore-Booth and Con Markiewicz (1927) [190 words] | 8 | 6 |
| Quarrel in Old Age (1931) [72 words] | 1 | 11 |
| Parnell's Funeral, Part I (1933) [247 words] | 4 | 33 |
| A Model for the Laureate (1937) [142 words] | 4 | 18 |

In nine of the 10 poems the count is higher in the appropriate age category. The probability of 9 or more correct binary choices from 10, under a Null Hypothesis that there is an even chance of being right or wrong, is 11/1024 (p=0.0107), suggesting that short substrings can indeed be useful in this sort of problem.

*5.2 A Youthful Yeatsian Index*

Of course ideally in stylochronometry we would want not just to classify texts as early versus late, but to assign an estimated date to each text. With this object in mind, a `youthful Yeatsian index' (YYIX) was defined as follows

$$YYIX = (YY - OY) / (YY + OY)$$

where YY is the number of younger-Yeats markers found and OY the number of older-Yeats markers. (This time only 19 substrings were used -- omitting `hat ' from the list shown in Table 3 on the grounds that both `what' and `that ' were already present -- to avoid any suggestion of double-counting.) In addition, three more unseen poems were added to the 10 listed in Table 4, to give a more balanced distribution across Yeats's career, including his middle period. These were *The Ragged Wood* (1904, 105 words), *All Things can Tempt me* (1908, 92 words) and *The Scholars* (1915, 73 words).

Figure 1, below, shows a plot of YYIX against date of composition. The correlation of YYIX with date is r = -0.844 which is very highly significant ($p < 0.001$). A regression using YYIX to predict date accounts for over 71% of the variance.

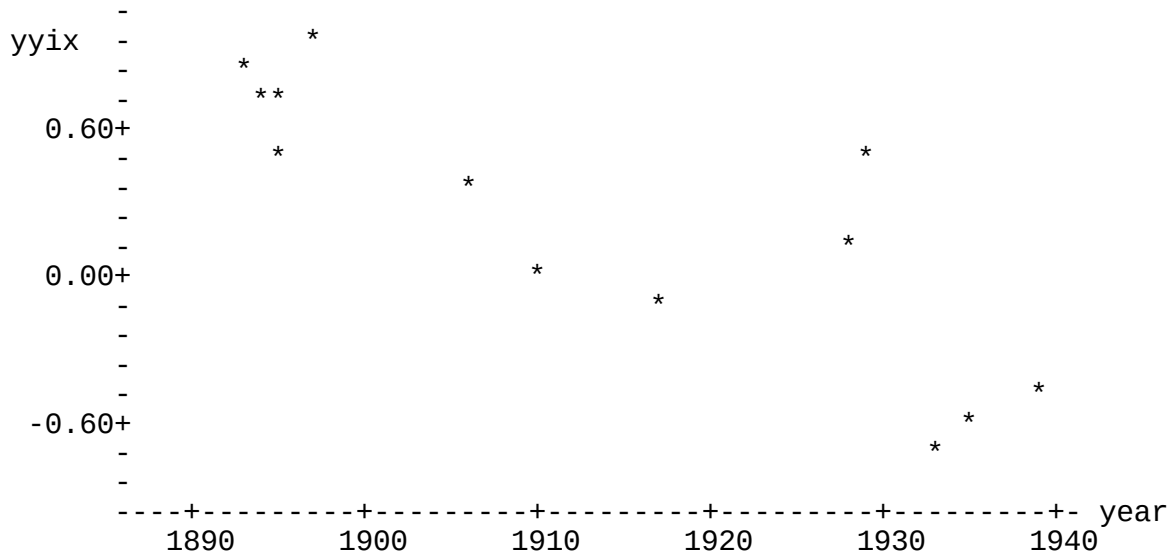


**Figure 1 -- Plot of Youthful Yeatsian Index against Date.**

*5.3 Visions and Revisions*

Another test of this approach involved looking at poems revised by Yeats in his later years. In the edition used here (Albright, 1990) there are just two such poems where the text of both versions is given in full. These are *The Lamentation of the Old Pensioner* (original 1890, revised 1925) and *The Sorrow of Love* (original 1891, revised 1924).

Table 5 gives the frequencies of YY and OY substrings in both versions of both these poems.

**Table 5 -- Substring Frequencies in Revised Poems.**

| | YY markers | OY markers |
|---|---|---|
| The Lamentation ...<br>1890 version<br>1925 version [95 words] | <br>2<br>0 | <br>2<br>11 |
| The Sorrow of Love<br>1891 version<br>1924 version [96 words] | <br>13<br>2 | <br>0<br>6 |

In each case Yeats's process of revision increases the number of `older-Yeats' markers and decreases the number of `younger-Yeats' markers.

*5.4 Prose Trial*

Although the training files used by TEFF to find distinctive substrings were entirely composed of poetry, it was thought worthwhile to look briefly at the frequencies of these marker substrings in prose passages as well, to gain an initial idea of the robustness of this approach when assumptions about genre are violated. Accordingly, two short extracts of prose were taken from the first and last essay by Yeats in the collection of Jeffares (1964), namely the first 40 lines of *The Irish National Literary Society* (446 words, dated 1892) and the first 44 lines of *Ireland after the Revolution* (435 words, dated 1938).

In the earlier extract, there were 21 YY markers and 11 OY markers. The later passage contained 11 YY markers and 36 OY markers. Of the 11 YY substrings, 7 were more frequent in the earlier piece than the later (with 3 tied in frequency). Of the 9 OY substrings, four were more frequent in the later piece than the earlier (with 4 tied). To put this another way: only 2 of the 20 markers pointed in the `wrong' direction.

**6. Discussion**

Counting `badges' in this manner is a rather unsophisticated method of text classification, so the performance of the marker substrings found by TEFF on the trials described above is quite impressive, especially bearing in mind the unreliability of most previous stylometric techniques on samples as small as those analyzed in this study -- as witnessed (for example) by the following quotation.

> "Even using 500 word samples we should anticipate a great deal of unevenness" (Ledger & Merriam, 1994).

Weaknesses still remain. Firstly, the presence of `hat ' as well as ` that' in the list of OY markers suggests that the post-filtering program still needs improvement. There is clear overlap between these two substrings, which introduces an undesirable element of double-counting. Secondly, and perhaps more important, interpretation of markers like `though' is problematic. The question arises: does a group of words such as

`though', `although', `thought' and `thoughtful' constitute a *natural kind*? And if not, are we justified in relying on such a heterogenous grouping? The answer must depend, in large part, on what we want to do with the texts under scrutiny. If insight is our aim, then a KWIC index based on the substrings in question should enlighten us about just what verbal habits are being detected. If accuracy of estimation is our prime concern, the standard statistical technique of cross-validation (Weiss & Kulikowski, 1991) should protect us from jumping to spurious conclusions.

## 7. Conclusion

To conclude: assigning short poems by W.B. Yeats to their correct chronological period is a non-trivial task. Nevertheless, a simple count of distinctive substrings found by the TEFF program led to the right assignment in 9 out of 10 unseen cases. Moreover, an easily calculated numerical index (YYIX) contrasting younger-Yeats with older-Yeats markers showed a highly significant correlation (r = -0.844) with the date of composition of 13 poems (median length = 114 words) in a genuine out-of-sample test. In addition, these substring frequencies were sensitive enough to detect authorial revision in two early poems revised by Yeats many years after he originally wrote them, and robust enough to classify a pair of short prose extracts correctly as well.

The performance in this pilot study of short substrings found by a Monte-Carlo process suggests that such strings warrant further investigation as stylistic indicators.

Further work along these lines is planned. Firstly, it is necessary to check whether this empiricist approach works well with other genres, e.g. prose, with other authors, and preferably also in other languages. Assuming these further trials confirm that this approach does work in practice, it will then become desirable to explore ways of linking the low-level markers found by the Monte-Carlo process with higher-level linguistic constructs, in order to make the results found easier to interpret.

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**Figure 1.**