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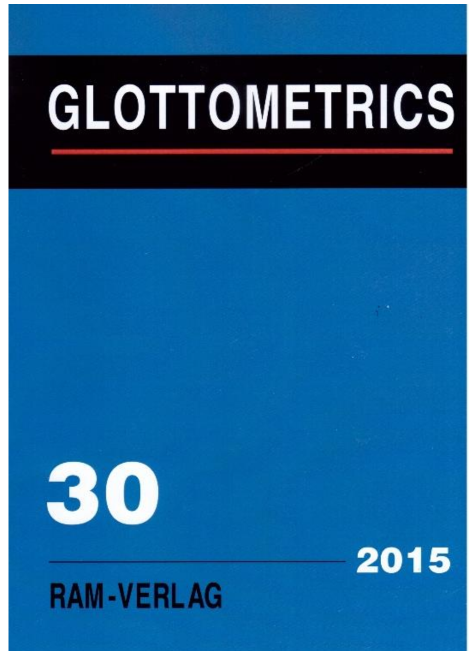

Finnegans Wake Seen from the Angle of Mathematics

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$$\Lambda^* = \frac{L^*}{N} Log_{10}(N) = \frac{(V + f_1 - (h+1)) Log_{10}(N)}{N}$$

Joyce Lexicography
Volume 113

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Finnegans Wake Seen through the Angle of Mathematics

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Reprinted from *Glottometrics* 30/2015, RAM-Verlag, pp19-44. **Glottometrics** is a scientific journal for the quantitative research on language and text, published by RAM-Verlag.

This text deals with the relationship between literature and mathematics. It is the first of a series of articles that address the structure of the book *Finnegans Wake* by James Joyce. The authors' main aim is to find out whether, in a text of this sort, linguistic laws are strong enough to counteract Joyce's extended idiosyncrasies, whether the usual mathematical models are still valid.

James Joyce began his writing career in 1914, and ended it with the publication of *Finnegans Wake* in 1939, after he had worked for 17 years on his last book. Joyce was the main representative of 20th Century Experimentalism, in everything he wrote. He began with the use of interior monologue and reached, in *Finnegans Wake*, the

Acest text scris de mai mulți autori se ocupă de relația dintre literatură şi matematică. El este primul dintr-o serie proiectată de articole care discută structura cărții *Finnegans Wake* de James Joyce. Intenția autorilor este să stabilească dacă într-un text de această factură legile lingvistice sunt îndeajuns de puternice pentru a îmblânzi proliferarea copleşitoare a vocabularului — cu alte cuvinte, dacă modelele matematice obişnuite sunt şi aici operaționale.

James Joyce a început să scrie în anul 1914. Ultima lui carte, publicată în 1939, a fost *Finnegans Wake*, la care a lucrat timp de 17 ani. Joyce este un reprezentant major al Experimentalismului secolului XX în literatură. De la bun început, el s-a folosit de monologul interior. În *Finnegans* most formidable concentration of it: almost every word in his last book was a simultaneity of private thoughts, associations and suggestions of all kinds. Those words, in their largest majority, did not exist in the English language, or in other languages, for that matter. Joyce himself created them. *Contemporary Literature Press* has published these "words" in Volumes 107-112 of the series *Joyce Lexicography*.

The fact that Joyce ended up creating a language of his own, which, however, could and did address all readers, is a good reason for this attempt at keeping count of those words by means of **quantitative methods**, which might shed light on a number of things that literary criticism has not seen so far.

Wake găsim forma cea mai concentrată a acestui monolog: fiecare cuvânt folosit acolo este o simultaneitate de gânduri, asociații şi sugestii de toate felurile. Într-o covârşitoare majoritate, aceste cuvinte nu există în limba engleză ca atare, şi nici în alte limbi. Ele sunt create de Joyce. *Contemporary Literature Press* a publicat aceste „cuvinte" în volumele 107-112 din seria *Joyce Lexicography*.

Aşadar, Joyce a sfârşit prin a-şi crea un limbaj propriu, care se adresa, însă, tuturor cititorilor. Articolul pe care îl publicăm acum se ocupă tocmai de acest limbaj, folosindu-se de metodele **lingvisticii cuantice**. Sperăm că aceste metode vor deschide noi drumuri acelora ce se ocupă de cercetarea cărții *Finnegans Wake.*

George Sandulescu and Lidia Vianu

PRECIS OF FW BY JAMES JOYCE IN STRAIGHT SHAPE.

REVISED VERSION

For 17 years solid James Joyce worked hard at his borogoves.

There were also mimsies, and last but not least, a vast amount of slithy toves. Most were hierarchically organized, but the borogoves had the upper hand. We should not forget the wabes and blades, but right at the top were the mome raths.

It would take another hundred volumes or so to analyse each of these categories in great detail, and which indeed did not at all carry the upper hand.

But I personally am fascinated between the relations between the borogoves on the one hand, and all the rest taken together on the other hand.

The wabes form a fascinating colony of words, but they are far too difficult for the man in the street.

A discussion of wombats is another matter altogether.

ends

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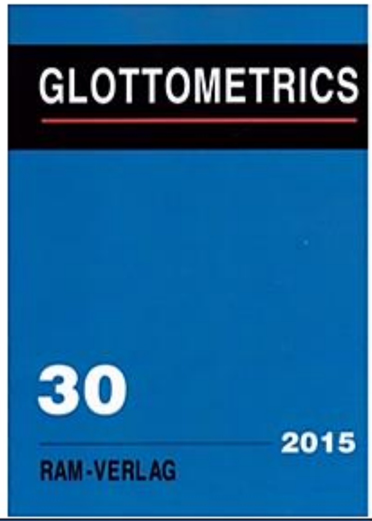

Finnegans Wake Seen from the Angle of Mathematics

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MATHEMATICS

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For if the lingo gasped between kicksheets, however **basically English**, were to be preached from the mouths of wickerchurchwardens and metaphysicians in the row and advokaatoes, allvoyous, demivoyelles, languoaths, lesbiels, dentelles, gutterhowls and furtz, where would their practice be or where the human race itself were the Pythagorean sesquipedalia of the panepistemion, however apically Volapucky, grunted and gromwelled, ichabod, habakuk, opanoff, uggamyg, **hapaxle, gomenon**, ppppfff, over country stiles, behind slated dwellinghouses, down blind lanes, or, when all fruit fails, under some sacking left on a coarse cart?

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Quantifying Joyce's *Finnegans Wake*

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Abstract. The aim of the article is to show that the quantitative indicators already applied to many texts are useful also for characterizing a special text containing many artificial components created by J. Joyce.

Keywords: James Joyce, Finnegans Wake, English, quantitative properties

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1. Introduction

James Joyce (1882-1941) began his writing career in 1914, and ended it with the publication of *Finnegans Wake* in 1939, after he had worked for 17 years on his last book. Throughout his career, Joyce experimented with poetry, plays and prose and his writings were influenced by a variety of factors. These included, but were not limited to, the political instability of Ireland at the time, the Irish literary and cultural revival of the late 19th century, and the European shift towards a more experimental style of literature (Spinks, 2009: 1-14). Indeed, his contributions to this new experimentalism have led some literary critics to praise him very highly, for example describing him as "the greatest and most enigmatic literary figure of the twentieth century" (Spinks, 2009: 1).

Joyce achieved arguably the most formidable concentration of this experimentation with his book *Finnegans Wake.* Considering the lexis alone, the book mixes standard English lexical items with neologisms, portmanteaus and polyglot puns. Furthermore, many different languages are represented (see Christiani, 1966; O'Hehir, 1967). However there are also other aspects that can present difficulties for a reader, for example Joyce writes simultaneously on different narrative planes and draws upon private experiences. Due to its idioscyncrasy, when *Finnegans Wake* was first published, the response it received was largely bemused or unfavourable; however, it is now viewed by some as postmodern triumph (c.f. Levin, 1944: 124; MacCabe, 1979: 133). Despite this, it remains one of the most controversial literary texts of our times.

The large majority of previous literary criticism of *Finnegans Wake* has taken a qualitative approach and focused on specific stylistic aspects of the work (see Campbell and Robinson, 1947; Benstock 1969; DiBernard, 1980). Some works could be considered to have taken a slightly more quantitative approach, by systematically considering the text and attempting to capture the size of it. For example, Glasheen (1956) created a census of biographical information of the characters in *Finnegans Wake* and Hart (1962) created a primary index of the 63,924 words in the vocabulary, an alphabetical list of syllables in the compound words and also listed some 10,000 English words suggested by Joyce's puns and distortions. However such analyses are still heavily qualitative in their methodology. This paper, the first in a series of articles, will offer a new perspective to the study of *Finnegans Wake* through taking a quantitative approach in order to consider the relationship between the author's creativity and language laws.

Whilst writing is a creative process, there is evidence to suggest it is constrained by language laws (see Zipf, 1935). These language laws can be seen as comparable to those in physics; however, whilst there are thousands of physicists trying to find laws in their field, there are a small number of linguists attempting to do the same for language laws. Fortunately, there are already several steps made by Köhler (2012) into the depth of syntax, and statistical evaluations from different domains (cf. Bybee, Hopper 2001, cf. also Janda 2013). In this study, our main aim is to state whether, in a text of this sort, linguistic laws are strong enough to soften the exuberant self-organization in the vocabulary, to establish whether the usual mathematical models used to analyse texts are still valid.

2. Methodology

The Joycean texts and word frequencies used in the present article are provided by Sandulescu and Vianu (James Joyce: Finnegans Wake. Full Text. Contemporary Literature Press, posted on Internet at the addresses given in References).Most word frequency data in the present article were obtained with http://www.writewords.org.uk/word_count.asp, after removing apostrophes, hyphens, and accents from the text. We shall call these words "mechanical words".

To explore stratification (see sections 2.3 and 3.3) it was necessary to consider the proportion of standard English words in the text. Therefore, for episode one, "original words" were used and classified as "standard English" or "Joycean word". This classification was agreed, out of context, with the joint judgements of two native speakers with backgrounds in English linguistics.

Through this paper, we analyse some of the quantitative properties of *Finnegans Wake*, using methods that have been used in similar studies previously. Through this, we enable the reader to perform comparisons of these texts. Below, we give a theoretical description of the steps of our analysis. Please note, this is not intended to be an exhaustive analysis; it is a beginning of a complete quantitative description of Joyce's work.

2.1 Rank-frequency distribution

There are several laws that attempt to capture the regularities that seem to exist in the frequency structure of texts, by expressing the relationship between frequency and rank of words in a text. Zipf (1935) carried out a systematic investigation of several languages and found a stable relationship between rank and frequency, which he expressed through a power law function. Researchers have since built on Zipf's work (see Popescu, Altmann and Köhler, 2010), attempting to explain it further and find an equation that better expresses the relationship. It is now common practice for the rank-frequency distribution of a text to be modeled by the Zipf-Mandelbrot distribution, which is a normalized extended Zipf-distribution (cf. Wimmer, Altmann 1999a: 666). We will therefore use this to present the rank-frequency distributions of words in the 17 episodes of *Finnegans Wake*.

2.2 The Lambda indicator

The Lambda indicator is derived from the sum of Euclidean distances between the neighboring frequencies of the rank-frequency distribution, i.e. as

(1) $$L = \sum_{r=1}^{V-1} [(f_r - f_{r+1})^2 + 1]^{1/2}$$

where L is the arc length of the word frequency distribution, V is the vocabulary (= highest rank) and f_r are the individual frequencies. Since this indicator increases with increasing text size N, it can be standardized by taking the ratio

(2) $$\Lambda = \frac{L}{N} Log_{10}(N)$$

yielding a relatively stable value independent of N.

Unfortunately, the variance of the Euclidian distance is a very lengthy expression containing the covariances, and it requires complex computing especially for text comparisons (cf. Popescu, Mačutek, Altmann 2010). In order to alleviate the use of Lambda, one found a simple approximation which minimally deviates from the Euclidean arc length and called it *simplified arc length* (Popescu, Altmann 2014)

(3) $$L^* = V + f_1 - (h + 1)$$

where h is the currently used h-point defined as

(4) $$h = \begin{cases} r, & \text{if there is an } r = f(r) \\ \dfrac{f(i)r_j - f(j)r_i}{r_j - r_i + f(i) - f(j)}, & \text{if there is no } r = f(r) \end{cases}$$

This point can be found and computed easily. Hence the standard *simplified Lambda* is defined as

(5) $$\Lambda^* = \frac{L^*}{N} Log_{10}(N) = \frac{(V + f_1 - (h+1))Log_{10}(N)}{N}.$$

Since in (5) the only variable is f_1 (V is given for the text and h is a fixed point), the variance of the simplified Lambda can easily be derived by expansion as

(6) $$Var(\Lambda^*) = \frac{f_1(N - f_1)(Log_{10}N)^2}{N^3}$$

For comparing two texts, one can use the asymptotic normal test defined as

(7) $$u = \frac{|\Lambda_1^* - \Lambda_2^*|}{\sqrt{Var(\Lambda_1^*) + Var(\Lambda_2^*)}}$$

The formulas are sufficient for characterizing the vocabulary richness in individual episodes of *Finnegans Wake*, identifying stylistic change within a text and performing comparisons between different texts. Needless to say, a work like the studied one does not arise spontaneously, so to say, in one go, but is steadily corrected, improved, parts are added or omitted, etc. Thus we obtain merely only a *grosso modo* image of the development, nevertheless, the whole is a true image of the vocabulary.

2.3 Stratification

Texts, partly due to characteristics of individual languages and partly due to language variability, are composed of a number of components. It is possible to confirm the existence of this stratification in a text through calculating the number of strata present at the word form level. Usually, this is done using the stratification formula (cf. Popescu, Altmann, Köhler 2010) defined as

(8) $$y = 1 + A_1 \exp(-x/r_1) + A_2 \exp(-x/r_2) + ...$$

in which the number of exponential components signals the number of strata. If two coefficients are equal, or if a coefficient presents a nonsense number, or if the determination coefficient R^2 attains a value greater than 0.9, the last component may be eliminated as redundant.

However, the stating of the number of strata does not mean the recognition and identification of strata, merely their existence and number (Knight 2013, p.36). However we will still carry out this analysis with *Finnegans Wake* as, firstly, the findings can still be compared with previous attempts and, secondly, the more texts that are analysed in this way, the more likely it is that we will be able to recognise and identify specific strata.

2.4 Ord's criterion

The aim of Ord's criterion (cf. Ord 1972) is to show that there is a unique structure if the values lie in a certain domain. The criterion has the form

(9) $$I = \frac{m_2}{m_1'}, \qquad S = \frac{m_3}{m_2},$$

where m'_1 is the mean and m_r are the central moments of r-th order.

2.5 Pearson's excess

Pearson's excess is used as the indicator of excess of the distribution. Using simply

$$(10) \qquad \beta_2 = \frac{m_4}{m_2^2},$$

without -3 which compares it with the normal distribution (cf. Kapur, Saxena 1970: 38).

2.6 Entropy and Repeat Rate

There are many definitions of entropy (cf. Esteban, Morales 1995). In our analysis, we use the best known measure, proposed by C. Shannon and applied currently in linguistics to show the diversity/uncertainty and the concentration of the distribution. This is defined as

$$(11) \qquad H = -\sum_{i=1}^{V} p_i \log_2 p_i$$

Here $p_i = f_i/N$, i.e. the relative frequencies of each word in the text. The variance of entropy can be obtained by expansion as

$$(12) \qquad Var(H) = \frac{1}{N}\left(\sum_{i=1}^{V} p_i \log_2^2 p_i - H^2\right)$$

It is possible to also use the natural logarithm. The entropy can be relativized dividing the value of H by its maximum which is simply $H_0 = log_2,V$, hence

$$(13) \qquad H_{rel} = H/H_0$$

and its variance is

$$(14) \qquad Var(H_{rel}) = \frac{Var(H)}{(\log_2 V)^2}.$$

Now, the greater is the diversity, the greater is vocabulary richness.

The Repeat Rate says asymptotically the same as the Entropy, but it is interpreted in reverse sense. If all frequencies are concentrated to one word, then the text is maximally concentrated. The smallest concentration is given if all words have the same frequency. The Repeat Rate is defined as

$$(15)\quad RR = \sum_{i=1}^{V} p_i^2 = \frac{1}{N^2}\sum_{i=1}^{V} f_i^2 \quad .$$

The maximum is 1, the minimum is 1/V, the relative Repeat Rate is

$$(16)\quad RR_{rel} = \frac{1-RR}{1-1/V},$$

and the variance is

$$(17)\quad Var(RR) = \frac{4}{N}\left(\sum_{i=1}^{V} p_i^3 - RR^2\right).$$

2.7 Writer's view

Other aspects of this methodology section have highlighted that authors shape their texts both consciously and sub-consciously. Some aspects of the writing process are subconscious because they take their course according to laws (not rules). Laws cannot be learned but they can be captured conceptually. One of such laws is the abiding by the "golden section" which can be defined as

$$(18)\quad \varphi = \frac{1+\sqrt{5}}{2} = 1.6180...$$

and in frequency analysis of texts it is represented by the so-called "writer's view" (cf. Popescu, Altmann 2007). One can imagine the writer sitting at a fixed point of the rank-frequency distribution and looking at the same time at the most frequent word (f_1) and at his vocabulary (V), i.e. the last word of the distribution. That means, his view encompasses an angle between his position - let us call it $P(h,h)$ - and the extreme points $P(1,f_1)$ and $P(V,1)$. The situation is visualized in Figure 1.

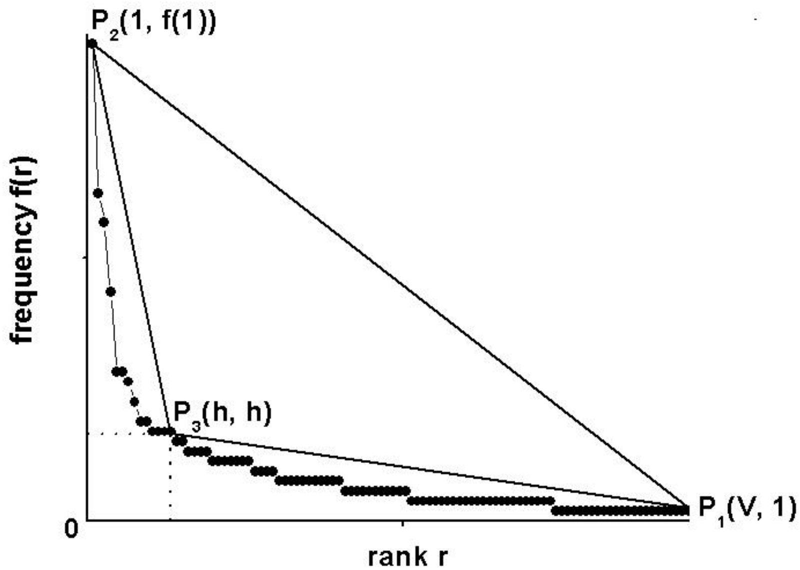

Figure 1. The writer's view angle ($P_2P_3P_1$)

The fixed point is defined as that point at which the rank and the frequency of that rank are equal. It is called h-point (cf. Popescu 2001). If there is no such point, it can be obtained by interpolation as shown in (6).

The cosine of the angle of the h-point can be computed classically as

$$(19) \qquad cos\,\alpha = \frac{-[(h-1)(f_1-h)+(h-1)(V-h)]}{[(h-1)^2+(f_1-h)^2]^{1/2}[(h-1)^2+(V-h)^2]^{1/2}}$$

and the radian of this angle is given as α *rad* = *arcos*(*cos* α). And this is exactly the value we call writer's view.

2.8 Vocabulary richness

In section 2.2, we outlined how we intend to analyse *Finnegans Wake* using the Lambda indicator. This will give us an indication of the vocabulary richness of the novel, however we wish to also use other methods to analyse this in more depth.

The number of indicators characterizing vocabulary richness is enormous. The concept itself can be interpreted in different ways, as can be seen in the history of its application (cf. e.g. Wimmer, Altmann 1999). Vocabulary richness may be considered as a function of any of the following: the number of different lemmas in text; the number of hapax legomena and the number of different tokemes (word form types). Alternatively, it is possible to study its evolution in text and perform several transformations. Regardless, text size N is always involved and this circumstance caused problems in the developing of indicators of richness (cf. Wimmer, Altmann 1999).

Popescu and Altmann (2006) introduced Gini's coefficient as a method of measuring vocabulary richness, as it takes into account all frequencies. However, frequencies play different roles. Fortunately, it is not necessary to revert and cumulate the distribution and the compute the sum of trapezoids to obtain the area above the Lorenz curve. Instead, one simply computes

$$(20) \qquad G = \frac{1}{V}\left(V + 1 - \frac{2}{N}\sum_{r=1}^{V} r f_r\right)$$

where V is the vocabulary (= highest rank), N is the text size, r is the rank and f_f the frequency of rank r. The authors defined a richness indicator as the complement to G, i.e.

$$(21) \qquad R_4 = 1 - G.$$

Since in (20) there are some constants (V and 2) and the mean, it is easy to define the variance as

$$(22) \quad Var(G) = Var(R_4) = \frac{4\sigma^2}{V^2 N}$$

where σ^2 is the variance of the distribution.

A quite different approach to vocabulary richness is considering the h-point. Words with ranks smaller than h are mostly auxiliaries, synsemantics and those (thematic) words which occur quite frequently but do not contribute to the richness. Richness is produced rather by words that occur seldom; in the history of this research one separated hapax legomena and considered them as unique indicators of richness. This is, of course, a slightly restricted view. But one can add also dis legomena or even tris legomena, but which of the approaches leads to "better" results? Where is the boundary?

Popescu et al. (2009: 29ff.) took into account the fixed point h and considered all words whose frequency is smaller than h (that is, the tail of the distribution) as contributors to richness. In order to obtain a comparable indicator we first define the cumulative probabilities up to h as

$$(23) \qquad F([h]) = F(r \le h) = \frac{1}{N}\sum_{r=1}^{[h]} f_r$$

That is, $F([h])$ is the sum of relative frequencies of words whose ranks are smaller or equal to h. A slight correction to $F([h])$ is the subtraction of the quantity $h^2/(2N)$, the half of the square of the h-point (cf. Popescu et al. 2009: 17). Using these conditions, one can define the indicator

$$(24) \quad R_1 = 1 - \left(F([h]) - \frac{h^2}{2N} \right)$$

Since in (24) the only variable is $F([h])$ which can be considered a probability, one easily obtains the variance of R_1 as

$$(25) \quad Var(R_1) = F([h])[1 - F([h])]/N.$$

This study will consider both of these approaches to vocabulary richness.

3. Results and analysis

3.1 Rank-frequency distribution

Unfortunately, the results of fitting the Zipf-Mandelbrot distribution are statistically not satisfactory. This may be due to some boundary conditions that has not been taken into account but also to the fact that the chi-square fitting has different weak points. However, considering the resulting formula as a simple function, we obtain a good result yielding $R^2 = 0.9964$.

Alternatively, it is possible to perform the fitting by means of a function known as Zipf-Alekseev function. One can obtain it from the differential equation

$$(26) \quad \frac{dy}{y} = \frac{A + B \ln x}{Dx} dx$$

which solved and reparametrized yields the function

$$(27) \quad y = cx^{a + b \ln x}.$$

In (26), A is the language/text-sort/style/,… constant, B is the force of the speaker/ writer and D is the equilibrating force of the community (cf. Wimmer, Altmann 2005). The check of sufficiency can be done again with the determination coefficient R^2.

Applying (27) to all episodes separately, we obtain the results presented in Table 1.

Table 1
Zipf-Alekseev Fitting (mechanical words)

Text	***a***	***b***	***c***	R^2
FW Episode 01	-0.6487	-0.0605	657.9873	0.9939
FW Episode 02	-0.5609	-0.0878	385.0283	0.9841
FW Episode 03	-0.5791	-0.0711	577.5572	0.9886
FW Episode 04	-0.6179	-0.0685	671.2932	0.9905
FW Episode 05	-0.6424	-0.0524	499.2077	0.9906
FW Episode 06	-0.4927	-0.0879	909.1371	0.9945
FW Episode 07	-0.5171	-0.0862	543.3030	0.9880
FW Episode 08	-0.3843	-0.1132	438.6174	0.9880
FW Episode 09	-0.4304	-0.0976	710.6777	0.9903
FW Episode 10	-0.5039	-0.0851	801.7924	0.9918
FW Episode 11	-0.6105	-0.0716	1674.9200	0.9945
FW Episode 12	-0.6983	-0.0575	487.0949	0.9595
FW Episode 13	-0.4000	-0.1034	490.0503	0.9876
FW Episode 14	-0.4322	-0.0902	902.7356	0.9959
FW Episode 15	-0.3987	-0.1032	1317.1361	0.9905
FW Episode 16	-0.4376	-0.0851	595.9386	0.9895
FW Episode 17	-0.5676	-0.0594	696.8380	0.9912

As can be seen, the parameters *a* and *b* are smaller than 0, and parameter *b* linearly depends on parameter *a*, namely $b = -\ 0.1683 - 0.1659a$ with $R^2 = 0.85$. This shows that even in such a non-standard text such as *Finnegans Wake*, the background law is followed subconsciously by the writer. It may be possible to insert the parameter *a* and its relation to parameter *b* in a more general theory encompassing language levels. However, it must further be scrutinized whether the negative values of *a* are characteristic only to the given text or are a general feature of rank-frequency distributions of words. Since this is possible only with a great number of other texts, we must, for now, renounce this task.

The results show that, in the example of this unusual text, the Zipf-Alekseev function yields a better fit than Zipf-Mandelbrot. The text, due to its use of non-standard words, has a large number of hapax legomena (words that occur only one time). The result suggests that modeling a rank-frequency distribution, especially in cases having very long tail, may be done more adequately with a simple function.

3.2 The Lambda indicator

In Table 2, the computed values are presented.

Table 2
Simplified Lambdas for individual episodes of *Finnegans Wake* (mechanical words)
(Note: the difference between the actual Λ and the simplified Λ* is a few per-mille)

Text	***N***	***V***	***f*(1)**	***h***	***L****	**Λ***	**Var (Λ*)**
FW Episode 01	9850	4107	642	32.0000	4716.0000	1.9120	0.00009865
FW Episode 02	6025	2798	375	24.0000	3148.0000	1.9750	0.00013841
FW Episode 03	9830	4363	580	32.5000	4909.5000	1.9940	0.00009003
FW Episode 04	10389	4443	659	31.0000	5070.0000	1.9602	0.00009225
FW Episode 05	8150	3419	491	28.6000	3880.4000	1.8622	0.00010627
FW Episode 06	16137	6243	898	42.0000	7098.0000	1.8508	0.00005766
FW Episode 07	9524	4153	535	29.8571	4657.1429	1.9456	0.00008813
FW Episode 08	8044	3477	419	28.5000	3866.5000	1.8772	0.00009362
FW Episode 09	14348	6166	692	39.6667	6817.3333	1.9751	0.00005528
FW Episode 10	15309	6619	777	41.2500	7353.7500	2.0103	0.00005512
FW Episode 11	25952	9986	1672	51.0000	11606.0000	1.9741	0.00004526
FW Episode 12	6176	2402	452	27.5000	2825.5000	1.7342	0.00015782
FW Episode 13	9551	3961	474	33.8000	4400.2000	1.8336	0.00007823
FW Episode 14	17658	6237	898	44.2500	7089.7500	1.7052	0.00004930
FW Episode 15	26921	9986	1262	52.0000	11195.0000	1.8422	0.00003257
FW Episode 16	12870	5307	577	39.5000	5843.5000	1.8659	0.00005619
FW Episode 17	12994	5271	709	39.0000	5940.0000	1.8805	0.00006718

For the sake of illustration we show the computation for Episode 1 and compare it with Episode 2. We obtain

$$\Lambda^*_{E1} = \frac{[4107 + 642 - (32.00 + 1)]\log_{10}(9850)}{9850} = 1.9120\,,$$

and

$$u = \frac{|1.9120 - 1.9759|}{\sqrt{0.00009865 + 0.0001381}} = 4.15\,,$$

a highly significant value, which suggests there is a stylistic difference between the two episodes. This could be the effect of multiple factors, for example a long pause in writing.

Comparing all episodes with one another, we obtain the results presented in Table 3 below. Instead of presenting all numbers, we mark (**X**) those pairs of texts whose *u* is smaller than 1.96, as this indicates that there is no significant difference of Lambdas and that the texts share similarity.

Table 3
Similarities of simplified Lambdas in 17 episodes of *Finnegans Wake*

Episode	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																	
2																	
3		X															
4		X															
5																	
6					X												
7		X		X													
8					X												
9		X	X	X													
10			X														
11		X	X	X					X								
12																	
13						X											
14																	
15					X	X							X				
16					X	X		X									
17					X			X								X	

Table 4 expresses this information in a different form, highlighting, for each episode, the number of other episodes it shares similarity with.

Table 4
Number of Lambda-similarities found for each episode of *Finnegans Wake*

Episode	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Number of similarities	0	5	4	4	5	4	2	3	4	1	4	0	2	0	3	4	3

The centrality (the stylistic gravitation of an episode) is the greater the more episodes are similar to it. Hence the sets of episodes according to decreasing centrality are

{2,5}, {3,4,6,9,11,16}, {8,15,17}, {7,13}, {10}, {1,12,14}.

It is clear that the episodes with the greatest centrality are 2 and 5, whereas the most divergent are episodes 1, 12 and 14. These results provide a new insight into the stylistic patterns found within *Finnegans Wake* and offer increased focus for a future qualitative study of the text.

Tables 5 and 6, below, show the mean and maximum lambdas calculated in previous studies for a range of text types.

Table 5
Mean lambdas of the rank-frequency distributions of some English writers
(taken from Popescu, Čech, Altmann 2011, Appendix, pp. 120 – 127)

Text sort	**# texts**	**mean Λ**
Table 6a: English poetry	18	1.4450
Table 6b: English prose	56	1.2922
Table 6c: English Nobel lectures	21	1.3079
Table 6d: English scientific texts	10	1.0528
Table 6e. English stories told by children	39	1.2651

Table 6
Maximal Lambdas in some works by English writers
(taken from Popescu, Čech, Altmann 2011, Appendix, pp. 120 – 127)

Text sort	**Genre**	**Text containing maximum Λ**	**Text author**	**maximum Λ**
Table 6a	Poetry	Howl (1956)	Ginsberg, A.	1.7905
Table 6b	Prose	Rosinante to the road again. XIV	Dos Passos, J	1.7679
Table 6c	Nobel	Literature (banquet speech) (1953)	Churchill, W.	1.6126
Table 6d	Science	Rorty's Inspirational Liberalism (2003)	Bernstein, R.J.	1.2412
Table 6e	Children	The Rift	Toni, boy, 11 years	1.5024

If we consider the maximum Lambdas for other texts, we see that the values seem to differ for different genres. Poetry has the highest value, followed by prose. Nobel and science have lower values. It seems reasonable to question whether the more a text deviates from realism in its content and the stronger is its creative component the greater its Lambda is. Our analysis of *Finnegans Wake* seems to fit with this hypothesis. Due to its play with words it is arguably the most creative text so far analyzed, and it has the highest scoring mean of Λ^* **(**1.8940) and highest scoring maximum of Λ^* (2.0103). Of course, a number of different texts in different languages would be necessary to test this further. The interested reader can perform further analyses concerning languages, text sorts, styles, development, etc. in order to obtain an overall image of this indicator (cf. Popescu, Čech, Altmann 2011).

Finally, Table 2 and Table 7 allow a comparison between Joyce's novels *Finnegans Wake* (1939) and *Ulysses* (1922), the latter written in standard English. The difference is enormous when one compares the Λ^* columns, the corresponding lambda averages being 1.8940 for *Finnegans Wake* versus 1,3671 for *Ulysses*.

Table 7
Simplified Lambdas for individual episodes of *Ulysses* (mechanical words)
(Note: the difference between the actual Λ and the simplified Λ* is a few per-mille)

Text	***N***	***V***	***f*(1)**	***h***	***L****	***Λ****	**Var (*Λ**)**
Ulysses Episode 01	7189	2043	399	30.3333	2410.6667	1.2932	0.00010846
Ulysses Episode 02	4394	1508	265	24.0000	1748.0000	1.4492	0.00017116
Ulysses Episode 03	5697	2320	284	25.0000	2578.0000	1.6995	0.00011727
Ulysses Episode 04	5874	2026	395	25.4000	2394.6000	1.5364	0.00015168
Ulysses Episode 05	6390	2026	353	27.7500	2350.2500	1.3997	0.00011828
Ulysses Episode 06	10903	2817	630	37.5000	3408.5000	1.2622	0.00008140
Ulysses Episode 07	10151	2840	638	34.0000	3443.0000	1.3589	0.00009314
Ulysses Episode 08	12903	3529	565	40.5000	4052.5000	1.2911	0.00005483
Ulysses Episode 09	11968	3491	626	39.0000	4077.0000	1.3892	0.00006888
Ulysses Episode 10	12442	3429	626	36.0000	4018.0000	1.3224	0.00006440
Ulysses Episode 11	12153	3205	432	38.0000	3598.0000	1.2093	0.00004707
Ulysses Episode 12	21274	5660	1608	49.5000	7217.5000	1.4683	0.00006152
Ulysses Episode 13	16755	3571	811	48.4000	4332.6000	1.0923	0.00004905

In order to state the significance of the difference we compute the asymptotic normal test between the means of the two simplified lambdas in the two tests according to

$$u = \frac{\bar{\Lambda}_1 - \bar{\Lambda}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

and obtain

$$u = \frac{1.8940 - 1.3671}{\sqrt{\frac{0.00763}{17} + \frac{0.02353}{13}}} = 11.0863$$

which is highly significant. Hence, *Finnegans Wake* strongly differs from a “normal” text.

3.3 Stratification

The results of the computation of strata in *Finnegans Wake* are presented in Table 8.

Table 8
The two-strata structure of rank-frequency distributions of words in all episodes
(mechanical words)

Text	***N***	A_1	r_1	A_2	r_2	R^2
FW Episode 01	9850	800.5245	2.4216	105.2927	31.3232	0.9956
FW Episode 02	6025	438.3131	2.9998	51.4478	33.2732	0.9910
FW Episode 03	9830	620.5005	3.0397	90.4213	33.5005	0.9848
FW Episode 04	10389	800.7309	2.3973	122.1213	27.2785	0.9906
FW Episode 05	8150	566.8180	2.8675	67.8039	39.9975	0.9897
FW Episode 06	16137	975.8178	3.0202	169.7285	32.5279	0.9920
FW Episode 07	9524	589.3728	3.2088	82.4540	35.7731	0.9900
FW Episode 08	8044	457.4715	3.1030	99.9073	28.2512	0.9911
FW Episode 09	14348	741.8399	3.3278	134.5352	35.0325	0.9917
FW Episode 10	15309	889.3433	2.9443	142.0732	34.7241	0.9951
FW Episode 11	25952	1973.5895	2.4524	297.9667	29.1142	0.9894
FW Episode 12	6176	664.7541	2.1508	67.7475	31.9517	0.9774
FW Episode 13	9551	503.3348	3.2776	105.1176	31.3593	0.9895
FW Episode 14	17658	903.1733	3.1081	211.5357	30.9411	0.9888
FW Episode 15	26921	1380.8318	3.1462	287.4493	32.8846	0.9900
FW Episode 16	12870	619.4422	3.2579	120.6342	37.8397	0.9931
FW Episode 17	12994	772.4971	2.4798	152.8376	31.4530	0.9846

As can be seen, the second coefficient r_2 is always greater than r_1, signaling the weak expression of the second stratum. The fitting is very adequate in all cases. Hence we can conjecture that there are two word strata in all texts.

To explore this further, we shall consider strata of original words (as defined in section 2). If we consider separately the frequencies of English words (eliminating all the others), we obtain again a two strata relation

$$y = 1 + 803.6911*\exp(-x/2.4385) + 102.3272*\exp(-x/30.6489)$$

with R^2 = 0.9960. Since the parameters are quite different, we have again two strata and may continue the procedure. But here, there are as many possibilities as we are able to define. Separating autosemantics and synsemantics would not finish the work. From the linguistic point of view, this would be a fertile way into the depth but from the textological view its relevance is not yet known.

Consider the non-English words, such as the most frequent ones: *willingdone*, *jinnies*, *lipoleums, prankquean, hoother,…* it is not easy to find a linguistic or textological criterion which would enable us to perform a classification. If we fit the stratification formula to this data, we obtain again two strata

$$y = 1 + 36.2053*\exp(-x/1.6548) + 3.4349(-x/39.7718)$$

with R^2 = 0.9783. Even a tri-stratal function yields non-equal parameters. Therefore much philological work would still be necessary to find the exact nature of the strata.

Since the difference of parameters may be caused also by the different size of data, we compute the lambda indicator for both and compare them. We obtain the results presented in Table 9.

Table 9
Simplified lambda for the three variants of Episode 1
(words separated by blanks)

All words (standard English and invented)						
N	***V***	***f*(1)**	***h***	***L****	***Λ****	**Var (*Λ**)**
9767	4146	642	31.6667	4755.3333	1.9425	0.00010009
Standard English words						
N	***V***	***f*(1)**	***h***	***L****	***Λ****	**Var (*Λ**)**
7562	2116	642	31.6667	2725.3333	1.3979	0.00015456
Joyce's invented words						
N	***V***	***f*(1)**	***h***	***L****	***Λ****	**Var (*Λ**)**
2205	2030	25	6.0000	2048.0000	3.1054	0.00005683

One can see that the frequency distribution of Joyce`s invented words has a much greater simplified lambda than the one of standard English words only. Performing the asymptotic normal test between the latter two distributions, we obtain

$u = |1.3979 - 3.1054|/[0.00015456 + 0.00005683]^{1/2} = 117.44.$

an extremely significant value whose probability is very small.

The above example supports the findings of section 3.2, through suggesting that lambda can be drastically increased by enriching the vocabulary with enough *x* unique words (actual or invented). The general formula results directly from the definition (5), namely

$$(28) \qquad \Lambda^*(x) = \frac{L^* + x}{N + x} Log_{10}(N + x)$$

To explore this further, we will draw on the example of the poem *Jabberwocky* by Lewis Carroll. Like *Finnegans Wake*, this text contains many words originally made up by the author. We used the values of *N* and *L**, given below in Table 10.

Table 10
Lambda for *Jabberwocky*

Lewis Carroll, Jabberwocky (1871)						
N	***V***	***f*(1)**	***h***	***L****	***Λ****	**Var (*Λ**)**
168	92	19	4.5000	105.5000	1.3974	0.00295660

We get

$$\Lambda^*(x) = \frac{105{,}5 + x}{168 + x} Log_{10}(168 + x)$$

in terms of *x* additional unique words as shown in Figure 2.

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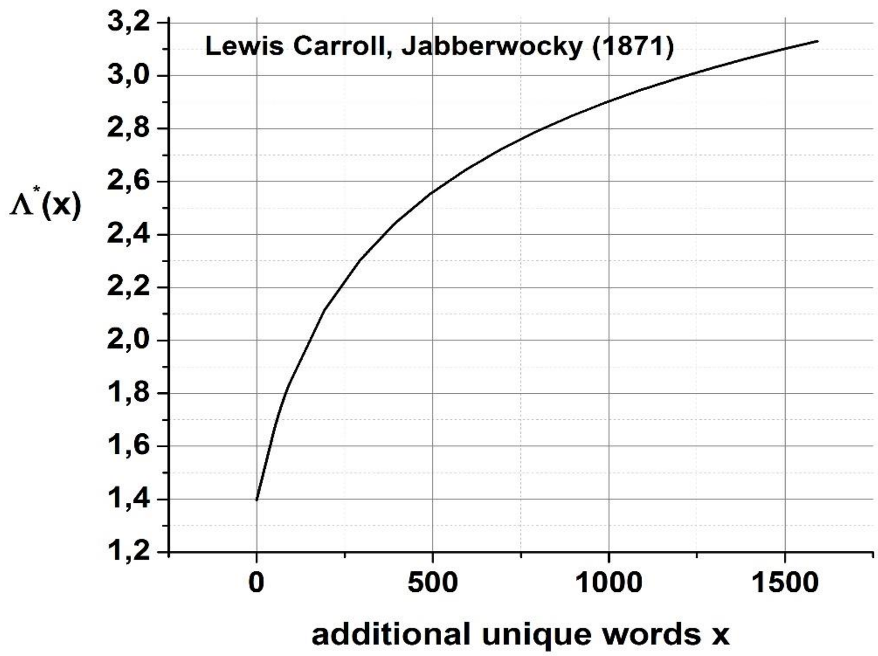

Figure 2. Lambda amplification by additional unique words

As it can be seen, a middle lambda text of about $\Lambda^* = 1.4$ can be increased to a lambda of about 3.1 by inserting about 1500 new unique words (hapax legomena). However, this freedom is given only to the text author, not to the researcher who must adhere to the state of affairs.

3.4 Ord's criterion

In Table 11 the values of Ord's criterion for each individual episode of *Finnegans Wake* are shown.

Table 11
Ord's criterion for individual episodes of
Finnegans Wake (mechanical words)

Episode	*N*	*V*	m_1'	m_2	m_3	*I*	*S*
1	9850	4107	18.3284	1403	142294	76.5266	101.4493
2	6025	2798	17.8944	1445	152210	80.7499	105.3374
3	9830	4363	17.4356	1358	140841	77.9017	103.6918
4	10389	4443	17.6995	1365	139515	77.1060	102.2289
5	8150	3419	20.1931	1586	158093	78.5312	99.6933
6	16137	6243	18.5976	1417	143401	76.1719	101.2280
7	9524	4153	18.4012	1450	148444	78.7856	102.3927
8	8044	3477	18.3802	1348	134480	73.3131	99.7993
9	14348	6166	17.6029	1334	135979	75.8000	101.9106
10	15309	6619	16.9289	1282	130904	75.7198	102.1209
11	26642	10676	16.0859	1193	121971	74.1423	102.2692
12	6176	2402	20.3339	1580	159757	77.6954	101.1219
13	9551	3961	18.9060	1429	144060	75.5798	100.8178
14	17658	6237	20.1035	1515	149985	75.3757	98.9796
15	27373	10438	17.6353	1320	133823	74.8546	101.3749
16	12870	5307	18.8625	1411	140567	74.7842	99.6493
17	12994	5271	19.7454	1482	145483	75.0404	98.1860

The relationship between *I* and *S* is visualized in Figure 3.

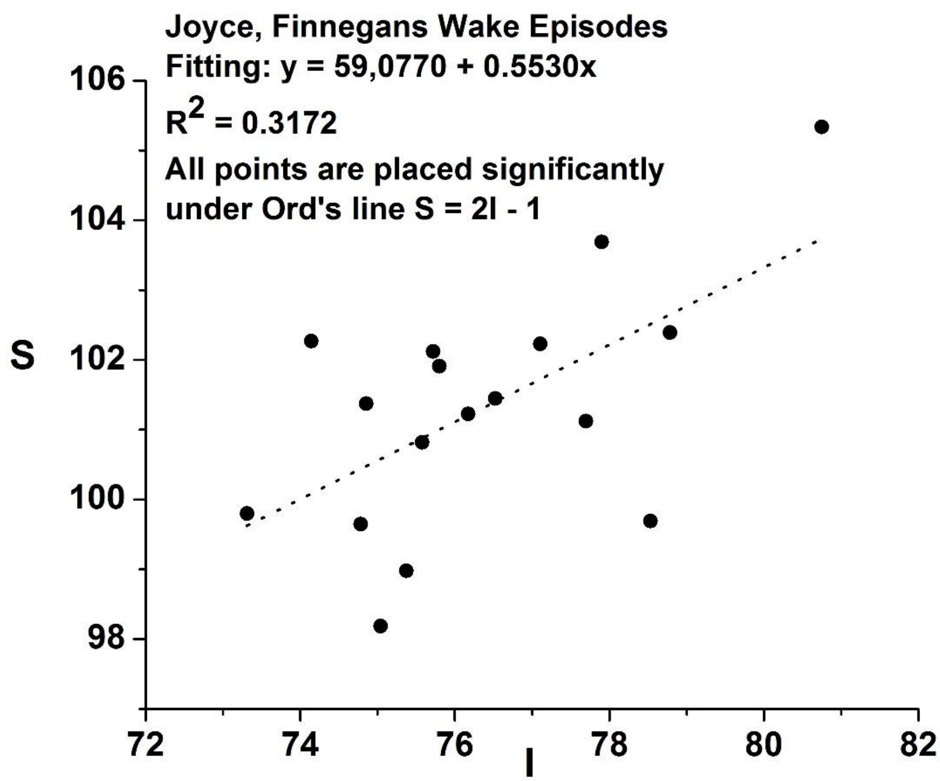

Figure 3. Ord’s criterion <I,S> for the individual episodes

Ord’s criterion displays a certain tendency but this tendency cannot be captured by a straight line. As can be seen in Figure 3, a very weak tendency exists.

The aim of Ord’s criterion is to show that there is a unique structure if the values lie in a certain domain. The separator of the domains is the line $I = 2S – 1$, separating the negative hyper-geometric domain under the line from several other ones. Since the <I,S> points are under the line, it would be interesting to substantiate linguistically its position. This is surely a task for the future; if one joined the neighboring points, one would obtain a strong oscillation which could be captured merely using some polynomials.

The aim of any indicator in text analysis is to identify some property of the given text, show its location in the two dimensional space, find its links to other indicators and show the inner mechanism controlling the self-regulation. Here, we must dispense with this aim because we analyze merely one text.

3.5 Pearson's excess

We obtained the results presented in Table 12.

Table 12
Pearson's excess

Episode	*N*	*V*	m_2	m_4	β_2
1	9850	4107	1403	19979792	10.1558
2	6025	2798	1445	21787444	10.4348
3	9830	4363	1358	19952925	10.8153
4	10389	4443	1365	19586475	10.5162
5	8150	3419	1586	22281134	8.8602
6	16137	6243	1417	20189479	10.0606
7	9524	4153	1450	20913274	9.9503
8	8044	3477	1348	18761611	10.3326
9	14348	6166	1334	19122332	10.7408
10	15309	6619	1282	18367567	11.1783
11	26642	10676	1193	17101986	12.0233
12	6176	2402	1580	22624458	9.0646
13	9551	3961	1429	20271044	9.9281
14	17658	6237	1515	21035004	9.1608
15	27373	10438	1320	18773335	10.7731
16	12870	5307	1411	19705541	9.9030
17	12994	5271	1482	20287021	9.2405

As can be seen, β_2 is almost constant. It does not bring any possibility of classification or modeling a development trend. A thorough comparison with other texts would show whether this property is constant also for "normal" texts.

3.6 Entropy and Repeat Rate

All values necessary for evaluation and comparison of Entropy and Repeat Rate for all individual episodes of *Finnegans Wake* are presented in Table 13 below.

Table 13
Entropy and Repeat Rate of individual episodes of *Finnegans Wake*

Text	*N*	*V*	*H*	Var(*H*)	*RR*	Var(*RR*)
FW Episode 01	9850	4107	9.7437	0.001166	0.010183	1.362E-07
FW Episode 02	6025	2798	9.5711	0.001619	0.009937	2.077E-07
FW Episode 03	9830	4363	9.9722	0.001123	0.008632	1.005E-07
FW Episode 04	10389	4443	9.8648	0.001124	0.009796	1.206E-07
FW Episode 05	8150	3419	9.7025	0.001236	0.008983	1.302E-07
FW Episode 06	16137	6243	10.0712	0.000793	0.008725	5.710E-08
FW Episode 07	9524	4153	9.9052	0.001138	0.008628	9.940E-08
FW Episode 08	8044	3477	9.5949	0.001324	0.009236	1.152E-07
FW Episode 09	14348	6166	10.2781	0.000837	0.007399	4.790E-08
FW Episode 10	15309	6619	10.3844	0.000801	0.007482	4.930E-08
FW Episode 11	26642	10676	10.5383	0.000585	0.009250	4.380E-08
FW Episode 12	6176	2402	9.0835	0.001678	0.013649	3.645E-07
FW Episode 13	9551	3961	9.7812	0.001114	0.008287	8.140E-08
FW Episode 14	17658	6237	9.9978	0.000706	0.008113	4.180E-08
FW Episode 15	27373	10438	10.5862	0.000526	0.007297	2.410E-08
FW Episode 16	12870	5307	10.1697	0.000851	0.006801	4.430E-08
FW Episode 17	12994	5271	10.0400	0.000882	0.007762	6.000E-08

As can be seen in Table 13, the richness of all episodes is relatively stable. That means, Entropy and Repeat Rate are effects of some laws working in the background; the writer abides by them unconsciously and creates them in spite of his originality. Though, in theory, there is a clear relationship between Entropy and Repeat Rate (cf. e.g. Altmann 1988: 45), in practice we obtain at least a power relationship as visualized in Figure 4.

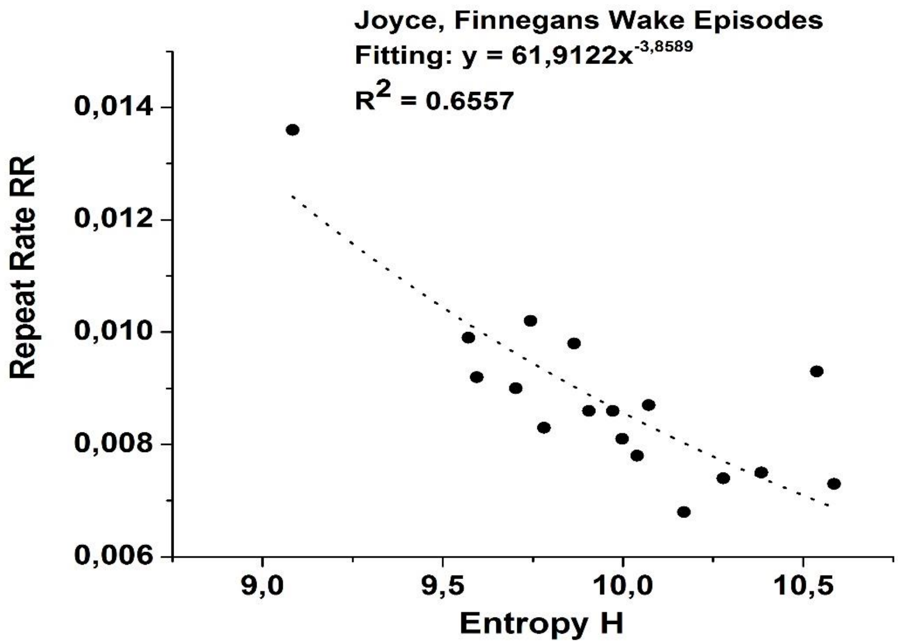

Figure 4. Entropy and Repeat Rate for *Finnegans Wake* episodes

This analysis will allow the mean Entropies or Repeat Rates of other works to be compared with *Finnegans Wake* using the variances, enabling new insights into these texts.

3.7 Writer's view

The computation of this value for the individual episodes of *Finnegans Wake* yielded values presented in Table 14.

Table 14
Writer's view of individual episodes of Finnegans Wake

Text	***N***	***V***	***f*(1)**	***h***	***cos α***	***α* rad**
FW Episode 01	9850	4107	642	32.0000	-0.0584	1.6292
FW Episode 02	6025	2798	375	24.0000	-0.0737	1.6445
FW Episode 03	9830	4363	580	32.5000	-0.0647	1.6355
FW Episode 04	10389	4443	659	31.0000	-0.0545	1.6253
FW Episode 05	8150	3419	491	28.6000	-0.0677	1.6386
FW Episode 06	16137	6243	898	42.0000	-0.0544	1.6253
FW Episode 07	9524	4153	535	29.8571	-0.0640	1.6349
FW Episode 08	8044	3477	419	28.5000	-0.0782	1.6491
FW Episode 09	14348	6166	692	39.6667	-0.0655	1.6363
FW Episode 10	15309	6619	777	41.2500	-0.0607	1.6316
FW Episode 11	25952	9986	1672	51.0000	-0.0359	1.6067
FW Episode 12	6176	2402	452	27.5000	-0.0734	1.6443
FW Episode 13	9551	3961	474	33.8000	-0.0826	1.6535
FW Episode 14	17658	6237	898	44.2500	-0.0576	1.6284
FW Episode 15	26921	9986	1262	52.0000	-0.0472	1.6181
FW Episode 16	12870	5307	577	39.5000	-0.0787	1.6496
FW Episode 17	12994	5271	709	39.0000	-0.0639	1.6347

Ordering the episodes according to increasing *N*, we obtain the course visualized in Figure 5.

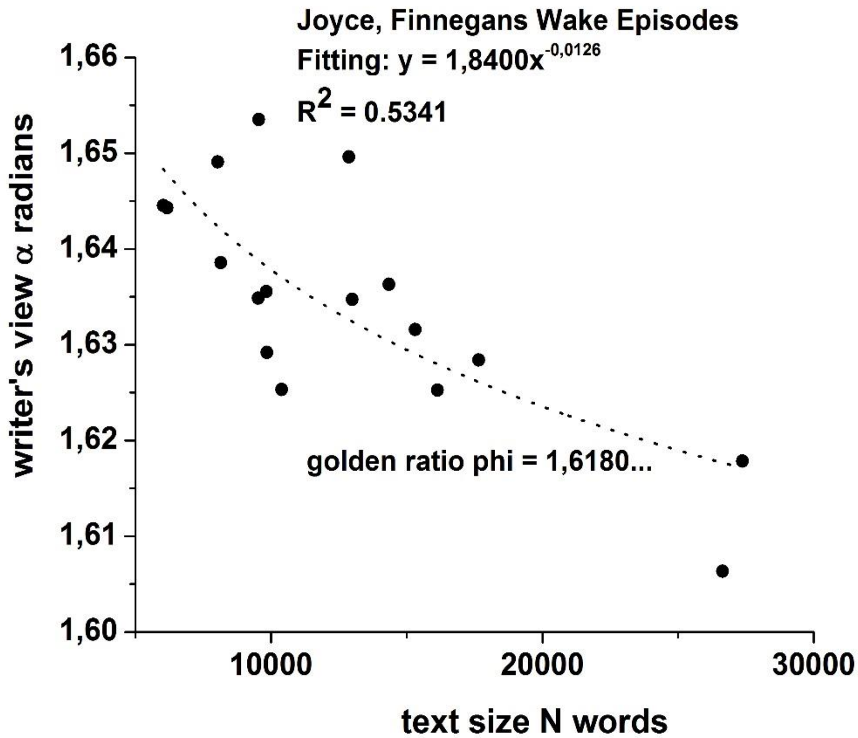

Figure 5. Writer's view for *Finnegans Wake* episodes

It has been shown in 20 languages and 176 texts that with increase of text size α *rad* converges to the value φ = 1.6180… that is, to the golden section (cf. Popescu, Altmann 2007). In all of the examined texts, α *rad* was situated in the neighborhood of this value. One cannot consider it a random event but rather a law concealed in some human senses and thinking.

The power function fitted to the data displays irregular oscillation but the direction is unmistakable. In the longest text (episode 15) α rad is almost identical with the golden section. Since the golden section exists also in other domains of human activity, it is not a purely linguistic phenomenon. Its origin should be sought somewhere in our evolution or in our physical and mental constitution. Nevertheless, comparisons of texts are possible because the parts of a text display different α rad, hence a textual whole has a mean and the individual parts have a spread which can be captured e.g. by the variance. The theoretical golden section is a constant having no spread.

When comparing *Finnegans Wake* with other texts, we may consider *Finnegans Wake* as expected values and use them for comparison in an asymptotic normal test. The mean "writer's view" of *Finnegans Wake* is $\overline{WW}$ (FW) = 1.6344 and the variance is Var (WW) = 0.00014401, hence Var ($\overline{WW}$) = 0.0001441/17 = 0.000008476. Comparing *Finnegans Wake* with *Ulysses*, also by Joyce, we obtained α rad = 1.5880, we obtain u = 15.94 which is, in spite of the small optical difference highly significant. However, Ulysses has been evaluated as a whole, not in parts.

3.8 Vocabulary richness

When considering vocabulary richness of each individual episode of *Finnegans Wake* using Gini's coefficient, we obtained the results presented in Table 15.

Table 15
Vocabulary richness of individual episodes
of *Finnegans Wake* using Gini's coefficient

Text	N	V	G	R_4	**Var(*G*)**
FW Episode 01	9850	4107	0.5643	0.4357	0.000034
FW Episode 02	6025	2798	0.5153	0.4847	0.000055
FW Episode 03	9830	4363	0.5383	0.4617	0.000034
FW Episode 04	10389	4443	0.5546	0.4454	0.000032
FW Episode 05	8150	3419	0.5575	0.4425	0.000041
FW Episode 06	16137	6243	0.5940	0.4060	0.000021
FW Episode 07	9524	4153	0.5453	0.4547	0.000035
FW Episode 08	8044	3477	0.5522	0.4478	0.000041
FW Episode 09	14348	6166	0.5544	0.4456	0.000023
FW Episode 10	15309	6619	0.5504	0.4496	0.000022
FW Episode 11	26642	10676	0.5850	0.4150	0.000013
FW Episode 12	6176	2402	0.5841	0.4159	0.000054
FW Episode 13	9551	3961	0.5653	0.4347	0.000035
FW Episode 14	17658	6237	0.6240	0.3760	0.000019
FW Episode 15	27373	10438	0.6009	0.3991	0.000012
FW Episode 16	12870	5307	0.5666	0.4334	0.000026
FW Episode 17	12994	5271	0.5764	0.4236	0.000026

Though one may see the slow linear decrease of R_4 and the F-test yields a significant result, fitting a straight line to the number in column R_4 yields merely R^2 = 0.36 and ordering according to increasing N improves slightly the linear tendency.

Popescu et al. (2009) analyzed and evaluated 173 texts in 20 languages using the same method. In other English texts, all Nobel lectures, R_4 was in the interval of 0.2640 and 0.4605. The mean the Nobel lectures was 0.3478. In comparison, the mean of *Finnegans Wake* is 0.4336. The difference seems to be quite great, but we shall not perform any further test here until it can be compared to a wider range of English texts.

Moving on, when we analyse vocabulary richness using formula (25) we achieve the results shown below in Table 16.

Table 16
Vocabulary richness in individual episodes of *Finnegans Wake*

Text	***N***	***V***	***h***	***F*([*h*])**	***R*₁**	**Var(*R*₁)**
FW Episode 01	9850	4107	32.0000	0.3709	0.6811	2.3689E-05
FW Episode 02	6025	2798	24.0000	0.3349	0.7129	3.6970E-05
FW Episode 03	9830	4363	32.5000	0.3517	0.7020	2.3195E-05
FW Episode 04	10389	4443	31.0000	0.3646	0.6817	2.2299E-05
FW Episode 05	8150	3419	28.6000	0.3401	0.7101	2.7538E-05
FW Episode 06	16137	6243	42.0000	0.3956	0.6591	1.4817E-05
FW Episode 07	9524	4153	29.8571	0.3464	0.7004	2.3772E-05
FW Episode 08	8044	3477	28.5000	0.3717	0.6788	2.9033E-05
FW Episode 09	14348	6166	39.6667	0.3671	0.6877	1.6193E-05
FW Episode 10	15309	6619	42.0000	0.3624	0.6952	1.5093E-05
FW Episode 11	25952	9986	51.0000	0.4054	0.6447	9.2883E-06
FW Episode 12	6176	2402	27.5000	0.3873	0.6739	3.8423E-05
FW Episode 13	9551	3961	33.8000	0.3729	0.6869	2.4484E-05
FW Episode 14	17658	6237	44.2500	0.4055	0.6499	1.3652E-05
FW Episode 15	26921	9986	52.0000	0.4004	0.6498	8.9179E-06
FW Episode 16	12870	5307	39.5000	0.3625	0.6981	1.7956E-05
FW Episode 17	12994	5271	39.0000	0.3773	0.6812	1.8081E-05

This method has previously been applied to 176 texts in 20 languages and yielded values for R_1 in the interval of 0.4308 and 0.9369 (cf. Popescu et al. 2009: Table 3.6). If we consider only the texts in English, they were in the interval of 0.6290 and 0.7545 with a mean of 0.6767. All of the episodes of *Finnegans Wake* are within the interval previously found for texts of English, yet have a little bit higher mean of 0,6829. This is to be expected since Joyce created many new words which were used only once, thus leading to a slight increase of the vocabulary richness R_1**.** This effect appears much more visible when the vocabulary richness is measured by lambda, as it results from the comparison of Table 2 for *Finnegans Wake* with Tables 5 and 6 for other English texts. Nevertheless, the almost infinite task to analyze all English texts remains an enterprise for the future.

Though the differences between R_1 of individual chapters are optically very small, it can be shown that some neighbouring episodes are significantly different. In Table 17 the R_1 of the neighbouring episodes are compared. The resulting value is the asymptotic u of the normal distribution.

Table 17
Normal tests for the differences of R_1 of the neighbouring episodes

Episodes	**u**
1-2	4.08
2-3	1.40
3-4	3.01
4-5	4.02
5-6	7.84
6-7	6.65
7-8	2.97
8-9	1.32
9-10	1.34
10-11	10.20
11-12	4.23
12-13	1.64
13-14	5.99
14-15	0.00986
15-16	9.31
16-17	2.81

All values greater than 1.96 signal a significant difference. As we saw in section 3.2, there is a significant different between episodes 1 and 2. However, if one draws a figure of R_1 for the episodes, one can observe a very strong oscillation, hence significant differences are not exceptional in this case.

If we compare all episodes with all other ones, we obtain a matrix displaying the similarities as shown in Table 18.

Table 18
Similarities of vocabulary richness as expressed by R_1

Id #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
1																	
2																	
3		X															
4	X																
5		X	X														
6																	
7		X	X		X												
8	X			X													
9	X			X				X									
10			X				X		X								
11																	
12	X			X				X	X								
13	X			X			X	X	X	X		X					
14						X					X						
15						X					X			X			
16			X		X		X		X	X			X				
17	X			X				X	X			X	X				

Table 19 expresses this information in a different form, highlighting, for each episode, the number of other episodes it shares similarity with.

Table 19
Number of similarities found for each episode of *Finnegans Wake*

Episode	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Number of similarities	6	3	5	6	4	2	6	6	8	5	2	6	9	3	3	6	6

As can be seen, there is quite a difference in the number of similarities shown by individual episodes. Episode 13 shares similarities with 9 other episodes, the highest scoring example, and is therefore the episode with the highest centrality in this instance. As can be seen, there is a great difference between the similarity in vocabulary richness computed in this way and using other indicators /cf. section 3.2).

A logical continuation of this study of centrality would be the comparison of concrete entities of Episode 13 with those of other ones. Unfortunately, the number of entities that could be compared is infinite and one would never know whether one found the pertinent ones.

The fact that R_1 and R_4 express the same property can be documented by their power relationship as visualized in Figure 6 below. It is worth noting that the Lorenz-curve is based on cumulative probabilities, too, but computed by an equivalent procedure. One can, of course, propose different other indicators (e.g. omitting synsemantics) but all must at least positively correlate with the above ones.

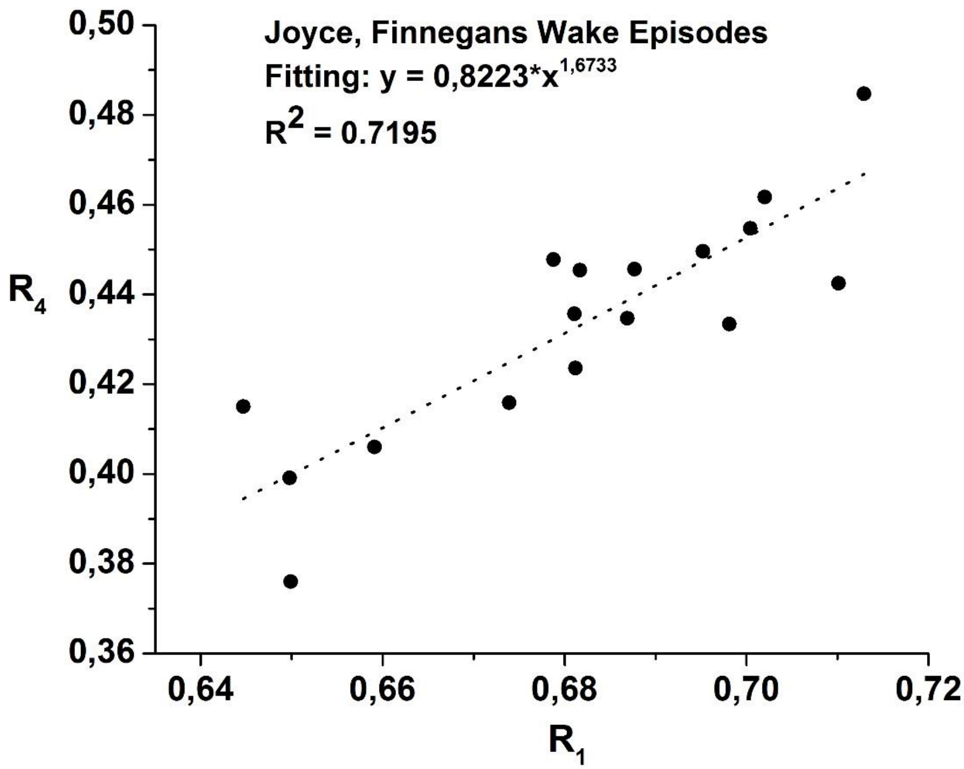

Figure 6. The relationship between R_1 and R_4

If there is at least a positive correlation between two indicators, one of them is sufficient for characterizing the text. But in that case one can show that the indicators merely show various aspects of the text and one can incorporate both in a synergetic control cycle. In special texts like FW, the dependence may be expressed by the difference between the parameters.

In order to obtain a wider perspective, we will also consider the link between R_1 and R_4 based on the data of Popescu et al. (2009), where 176 texts in 20 languages[1] were considered. The results are shown in figure 7.

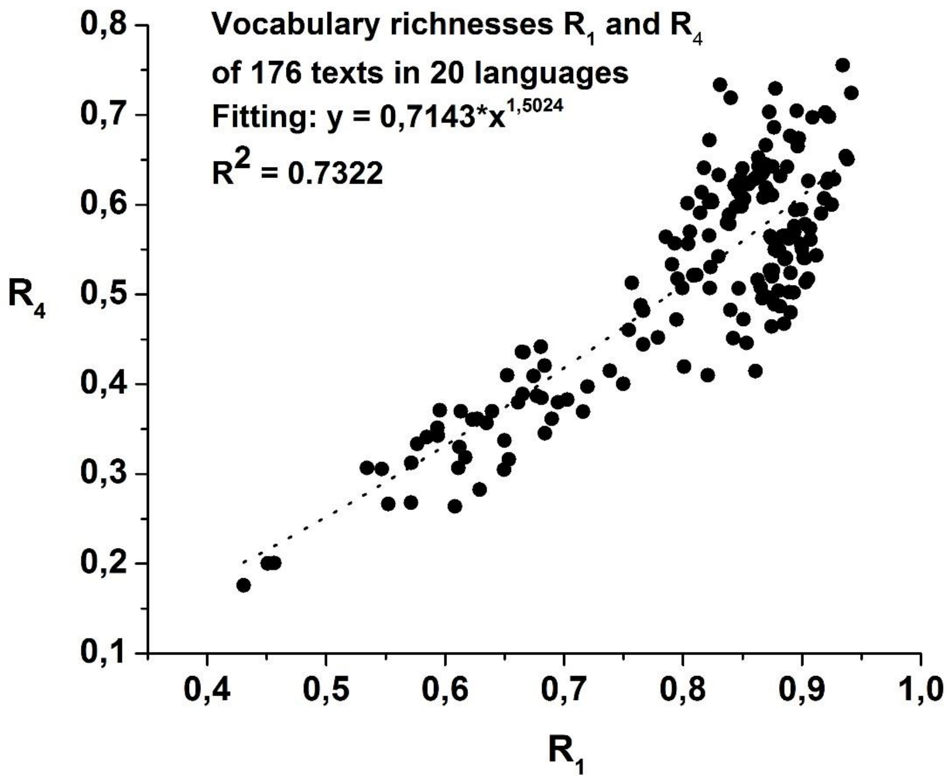

Figure 7. The link between R_1 and R_4 in 176 texts in 20 languages.

Richness cannot come into existence without influencing other properties. Finding those which are related with it may lead to a discovery of a law. To this end, a synthesis of all the computed above indicators of individual episodes of *Finnegans Wake* is presented in Table 20.

Table 20
Synthesis of all the above indicators
of individual episodes of *Finnegans Wake*

[1] The 20 languages included were Bulgarian, Czech, English, German, Hungarian, Hawaii, Italian, Indonesian, Kannada, Lakota, Latin, Maori, Marathi, Marquesan, Rarotongan, Romanian, Russian, Samoan, Slovene and Tagalog.

Text	N	V	Λ*	I	S	H	RR	R_1	R_4	α rad	β_2
FW 01	9850	4107	1.9120	76.5266	101.4493	9.7437	0.0102	0.6811	0.4357	1.6292	10.1558
FW 02	6025	2798	1.9750	80.7499	105.3374	9.5711	0.0099	0.7129	0.4847	1.6445	10.4348
FW 03	9830	4363	1.9940	77.9017	103.6918	9.9722	0.0086	0.7020	0.4617	1.6355	10.8153
FW 04	10389	4443	1.9602	77.1060	102.2289	9.8648	0.0098	0.6817	0.4454	1.6253	10.5162
FW 05	8150	3419	1.8622	78.5312	99.6933	9.7025	0.0090	0.7101	0.4425	1.6386	8.8602
FW 06	16137	6243	1.8508	76.1719	101.2280	10.0712	0.0087	0.6591	0.4060	1.6253	10.0606
FW 07	9524	4153	1.9456	78.7856	102.3927	9.9052	0.0086	0.7004	0.4547	1.6349	9.9503
FW 08	8044	3477	1.8772	73.3131	99.7993	9.5949	0.0092	0.6788	0.4478	1.6491	10.3326
FW 09	14348	6166	1.9751	75.8000	101.9106	10.2781	0.0074	0.6877	0.4456	1.6363	10.7408
FW 10	15309	6619	2.0103	75.7198	102.1209	10.3844	0.0075	0.6952	0.4496	1.6316	11.1783
FW 11	26642	10676	1.9741	74.1423	102.2692	10.5383	0.0093	0.6447	0.4150	1.6067	12.0233
FW 12	6176	2402	1.7342	77.6954	101.1219	9.0835	0.0136	0.6739	0.4159	1.6443	9.0646
FW 13	9551	3961	1.8336	75.5798	100.8178	9.7812	0.0083	0.6869	0.4347	1.6535	9.9281
FW 14	17658	6237	1.7052	75.3757	98.9796	9.9978	0.0081	0.6499	0.3760	1.6284	9.1608
FW 15	27373	10438	1.8422	74.8546	101.3749	10.5862	0.0073	0.6498	0.3991	1.6181	10.7731
FW 16	12870	5307	1.8659	74.7842	99.6493	10.1697	0.0068	0.6981	0.4334	1.6496	9.9030
FW 17	12994	5271	1.8805	75.0404	98.1860	10.0400	0.0078	0.6812	0.4236	1.6347	9.2405

4. Conclusion

In this study, our main aim was to state whether, in a text of this sort, linguistic laws are strong enough to soften the exuberant self-organization in the vocabulary, to establish whether the usual mathematical models used to analyse texts are still valid. Our analysis highlights that clearly even extraordinary texts, where the writer tries to deviate from the standard, follow some subconscious laws. We showed that it is possible to trace these laws by computing different indicators representing the degrees of some properties and searching for their links to other properties. In some cases, for example sections 3.2, 3.3, 3.4, 3.6 and 3.7, standard mathematical models could be used to achieve this. In such instances, it was possible to characterize the text as a whole, compare episodes and perform comparisons between different texts. This provided new insights into the structure and vocabulary of *Finnegans Wake* and presents opportunities for further analysis to be carried out. In others, the mathematical models needed to be adjusted or did not provide results consistent with any previously found data, limiting further analysis. This point highlights that the interpretation of all of our findings is limited by the amount of comparable data and, as summarised in section 1, few linguists are perusing the study of language laws. In every language there are some boundaries that cannot be surpassed; *Finnegans Wake* may represent such a boundary, but this can be stated once we can compare the results with thousands of texts in English and other languages.

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by C. George Sandulescu and Lidia Vianu

FW167.28

My unchanging Word is sacred. The word is my Wife, to exponse and expound, to vend and to velnerate, and may the curlews crown our nuptias! Till Breath us depart! Wamen. Beware would you change with my years. Be as young as your grandmother! The ring man in the rong shop but the rite words by the rote order! *Ubi lingua nuncupassit, ibi fas! Adversus hostem semper sac!*

FW 219.16:

And wordloosed over seven seas crowdblast in celtelleneteutoslavzendlatinsoundscript.

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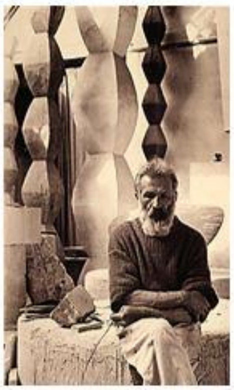

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