Punctuation effects in english and esperanto texts

M. AUSLOOS

previously at: GRAPES@SUPRATECS,
Université de Liège, Sart-Tilman,
B-4000 Liège, Euroland

nowadays at: 7 rue des Chartreux, B-4122 Plainevaux, Belgium

Abstract

A statistical physics study of punctuation effects on sentence lengths is presented for written texts: *Alice in wonderland* and *Through a looking glass*. The translation of the first text into esperanto is also considered as a test for the role of punctuation in defining a style, and for contrasting natural and artificial, but written, languages. Several log-log plots of the sentence length-rank relationship are presented for the major punctuation marks. Different power laws are observed with characteristic exponents. The exponent can take a value much less than unity (ca. 0.50 or 0.30) depending on how a sentence is defined. The texts are also mapped into time series based on the word frequencies. The quantitative differences between the original and translated texts are very minutes, at the exponent level. It is argued that sentences seem to be more reliable than word distributions in discussing an author style.

Key words: texts, sentence statistics, Zipf, ranking, translation, esperanto

1 Introduction

Since [1], there is a relatively interesting set of studies pertaining to the structure of written texts through techniques based on statistical physics ideas and methods, usually measuring the word length or/and word frequency distribution. Without claiming to be exhaustive, let us mention recent studies, much after 2000, on german [2], polish [3] english and irish [3–8], chinese [7–10], japanese [11], greek [12–14], turkish [15], hungarian [16], welsh [17], baltic and slavic [18], but also in less natural languages like fortran [19], artificial [20], or
Debates exist whether a few texts are sufficiently representative of a language and how big a lexicon must be before it becomes significant. This caveat presented, it is fair to say that several specific features of written texts have not been studied in detail. The role of punctuation on the structure of texts is one of these.

According to wikipedia the first inscription with punctuation mark is the Mesha Stele (9thBC); see http://en.wikipedia.org/wiki/Mesha_Stele. A long time ago Greeks and Romans adopted a few punctuation marks (the dot and combinations, essentially) in order to mark pauses in texts, to be played. Other historical details on the creation, dissemination, use and types of punctuations in various languages can be found in http://en.wikipedia.org/wiki/Punctuation, and http://grammar.ccc.commnet.edu/grammar/marks/marks.htm.

Through these e-references, it can be learned that punctuation marks are symbols that indicate the structure and organization of a written text in a specific language, for readability, as much as for suggesting intonation and pauses when reading aloud. In written English, punctuation is vital to disambiguate the meaning of sentences, though this does not go without problems [25,26].

Notice that some modern writers have attempted to go in some sense backward. As far as 1895, Crane published The Black Riders and Other Lines [27] in capital letters: the poems appearing without punctuation, an unusual typographical presentation for the time, - a style system considered as garbage by the critics. In another language, e.g. French, Apollinaire [28] published one of his major pieces Alcools without punctuation. Thereafter, Similarly, the French surrealists and dadaists scorned punctuation, like Aragon [29] who avoided any in most of his poems and prose for/about Elsa Triolet. That followed from the para-psychological theory put forward by Breton [30] in The Manifesto, containing new/practical recipes for enhancing the Magic Surrealist Art, such as: "...Punctuation of course necessarily hinders the stream of absolute continuity which preoccupies us ... ". This was recently "poetically" reformulated by Hahn [31] in The Pity of Punctuation poem. Some "maximum" was likely reached by Joyce [32]. In Ulysses symbolically conserving the structure of Homers The Odyssey, where there is no punctuation, Joyce omits punctuation entirely, in the last chapter of the novel, - consisting of eight long paragraphs, in order to mimic the uninterrupted flow of naked thoughts.

Thus punctuation could be avoided. Indeed there is some redundancy, since a capital letter can indicate to the reader a new sentence. One major difficulty
nevertheless occurs in text analysis: it is more easy to observe a punctuation sign on a text than a capital letter.

However, fundamentally, in literature, the marks are strongly depending on the writer choice [29,30,32], but also on the editor [33,34]. A question can thus be raised about the relationship, if any, between an author and the use of punctuation marks, for defining his/her style.

A few text studies seem to exist along these lines in the recent literature, i.e. having considered structures at the sentence level in english[1,7,8], in german [2], in chinese [8], in japanese [11], sometimes strangely neglecting the punctuation role as in [3,6]. In order to propose further studies on the matter, it is attempted here to discuss well known written texts. Moreover, as in [3,21] such considerations are extended to some translation of texts.

The texts here below chosen are freely available from the web [35], i.e. Alice in wonderland (AWL) [36] and Through a looking glass (TLG) [37]. They are representative of a well known mathematician Lewis Caroll. Such a choice will allow one to discuss whether the differences between two single author english texts, having appeared at different times (1865 and 1871), contain different structures. The first text is also available in esperanto [38,39]. It seems in order to observe whether some style or structural change has been made between a text and its translation, thus whether the translation observes similar statistical rules as the original text from the punctuation point of view. Previous work on the english AWL version should be here mentioned [24].

In Sect. 2, the methodology is briefly exposed. It is recalled that one can map texts into (word) length time series (LTS) or into a (word) frequency time series (FTS). In the present case one adopts the length time series approach in order to count the number of characters (and blanks) in a sentence, i.e. defining a time interval ending by some punctuation mark Some test with a FTS will be made. In Sect. 3, the results are presented through log-log plots of the sentence length-rank relationship and along a Zipf analysis for the word distribution. A conclusion with statistical and linguistics comments is found in Sect. 4.

2 Data and Methodology

For the present considerations two texts here above mentioned and one translation have been selected and downloaded from a freely available site [35], resulting obviously into three files. The chapter heads are not considered. All analyses are carried out over this reduced file for each text. As indicated in the introduction, one can look at the length of sentences, or bits of sentences,
by analogy with the original Zipf analysis method or technique which gives a rank \( R \) to the words according to their frequency \( f \) and make a log-log frequency-rank plot, one ranks here the sentences according to their length \( l \) (to be defined) and one searches for \( l(R) \). Usually, for many languages, written texts, one has \( f \sim R^{-\zeta} \), such that one roughly sees a straight line going through the data, o a log-log plot, interestingly with a slope \( \sim -1 \) [40]. A large set of references on Zipf’s law(s) in natural languages can be found in [41]. Thus, one considers that there is a one-to-one relationship between rank and frequency. This is strictly true if there is no ambiguity in the ranking; sometimes two (or more) words have the same frequency. Their rank has been attributed according to their chronological appearance in the text, apparently without much loss in information content.

As previously mentioned, this Zipf law and others have been mainly considered at the word distribution level; it is fair to reemphasize related work at the sentence level, defined through separation dots, e.g. on german [1,2], on irish [6,7] and on japanese [11] texts.

3 Results

In the present case, one considers the length \( l \) of sentences defined between various punctuation marks, counting characters rather than words. The punctuation marks define time intervals or bits of sentences. The result of the LTS rank-like analysis, a length-rank relationship, for the three main texts is shown in Figs. 1-3, for the different punctuation marks, as mentioned in the figure
Fig. 2. log-log plot of the rank-sentence lengths, as separated by (a) semicolons, (b) colons, in the three texts of interest AWLeng, AWSesp and TLGeng. The $\eta = 0.50$ exponent of the corresponding rank law is indicated as a guide to the eye.

Fig. 3. log-log plot of the rank-sentence lengths, as separated by (a) exclamation points, (b) question marks, in the three texts of interest AWLeng, AWSesp and TLGeng. The $\eta = 0.50$ exponent of the corresponding rank law is indicated as a guide to the eye.

Fig. 4. Zipf (log-log) plot of the frequency of words in the three texts of interest AWLeng, AWSesp and TLGeng. The usual ($\zeta = 1$) exponent is indicated.
captions. For pointing out the cases, it is seen that the longest "sentence" contains 1669, 825, and 864 characters, in AWLeng, AWLesp and TLGeng respectively, when the sentence ends with a dot, Fig. 1(a). Similarly the longest sentence contains 6323, 5581 and 5212 characters when ending with question mark, in the respective texts. Several orders of magnitude in the maximum rank and in the lengths immediately distinguish the cases. There about 2000, 200 and 500 ranks, i.e. different lengths, depending on the punctuation marks, grouped as in Figs. 1-3. On the other hand the length can vary much: from about 300 to 12000 depending on the cases.

At once it is observed that TLGEng slightly differs from others, when the sentences end with a semi-colon, Fig. 2(a). Interestingly let it be observed that the Rank =1 length for the esperanto text is often higher than for the english texts. This might be argued to originate from the number of available words to make any sentence. The number of words is less in esperanto indicating a greater simplicity in vocabulary: english contains ca. 1 M words [42], esperanto 150 k words [43].

Each log-log plot roughly indicates a simple power law relationship, for ca. \( R \leq 500, R \leq 50, R \leq 100 \), i.e. \( l \sim R^{-\eta} \). This corresponds to a break length value ca. 100, 1000 and 1000. Some curvature is found for all texts below \( R \sim 5 \) where a so called discontinuity exists. It can be understood in lines of comments by [24] on word frequency plots. For the latter case, this is due to a transition between colloquial ("common") small and "distinctive" words; one can be easily convinced of the analogy when forming and studying sentences. This weak change in curvature at low rank value feature is also explained in Mandelbrot [44–46] using arguments based on fractal ideas, applied to the structure of lexical trees. Some marked break, or change in slope, looking like a distribution truncation is also found for \( R \) large. Some discussion for the latter case in discussing word distributions can be read in [24]. By analogy this behavior is thought to arise from the scarcity of long sentences, i.e. there is much difference in the number of characters for the long sentences, not so much for the small ones. In some physics-like sense one would attribute the result to the polycrystalline nature of the sample, made of few big crystals and many tiny ones.

The most drastic difference occurs between the cases of the first group of punctuation marks, Fig. 1, where the slope indicates that the exponent \( \eta \) is rather close to 1/3, and the latest four cases, Fig. 2-3, where the slope is closer to 1/2. Notice that the number of punctuation marks is relatively equivalent in all texts, as estimated from the integral of the distributions [47], but there are many more dots and commas than other punctuation marks, as is expected indeed, - a factor of ten. Therefore one might expect some stronger finite size effect influencing the exponent value in the latter cases.
In conclusion of this section, let it be accepted that the quality of the power-law fits are less impressive in the case of the length of sentences (Figs. 1-3) than in the case of the frequency of words (Fig. 4). This observation possibly indicates that the existence of a cut-off is more likely, for the length of sentences, because of grammatical and readability constraints. One could alternatively present the data in a log-normal plot, and observe whether a stretched exponential can be considered. However the shortness of the data range is in this case a handicap as well. Further "theoretical" discussion on the values of the exponents as found below in Sec. 4 would not be more agreeable. The possible stretched exponential is thus below briefly discussed.

4 Conclusion

The occurrence of such a power law for word distributions has already been suggested [48] to originate in the "hierarchical structure" of texts as well as to the presence of long range correlations (sentences, and logical structures therein). Some ad hoc thought has been presented based on constrained correlations [49,50]. A value of $\eta$ smaller than unity indicates a wide, flat distribution thus a more homogeneous repartition of the variables (lengths of sentences, here).

Gabaix [51], looking at city growths, claims that two causes can lead to a value less than 1.0, i.e. either (i) the growth process deviates from Gibrat’s law [52] which assumes that the mean growth rate is independent of the size, or/and (ii) the variance of the growth process is size-dependent. Recall that one does not examine the "growth" of the text at this stage yet, nor have any model for doing so presently.

However, one can imagine the way L. Caroll (and other authors) function. After writing a first draft of some chapter, the author adds, removes, modifies words and sentences, introducing different "grams" leading to a modified story development and text structure. Modifying again the text after a second reading, etc. The process is kinetic indeed and basically a growth process, somewhat similar to city growth; Thus it is a priori hard to say whether the causes (i) or (ii) or both are influencing the exponent values.

One can nevertheless debate whether the sample size is relevant for estimating a (small) $\eta$ value on so few rank decades [47]. The same can be considered if the data would seem to fit a stretched exponential. If so it might be argued that an external constraint must be envisaged, as if the writer was influenced by e.g. the size of the paper sheet on which he/she is writing. The present author wishes not to enter into such considerations, though further studies might be of interest nowadays as when studying blogs and RSS [53] and other
(electronic or not) reports which are strictly limited in size or in the number of allowed characters.

According to a widespread conception, quantitative linguistics will eventually be able to explain such empirical quantitative findings (such as Zipf law) by deriving them from highly general stochastic linguistic laws that are assumed to be part of a general theory of human language [54,55] for a summary of possible theoretical positions). In [56], Meyer argues that on close inspection such claims turn out to be highly problematic, both on linguistic and on science-theoretical grounds. It has also been argued that it is possible to discriminate between human writings [57] and stochastic versions of texts precisely by looking at statistical properties of words. In contrast I argue here above that this statement can be extended to sentence statistics.

The meaning of the results is admittedly still somewhat elusive, even though the length distribution of text segments between certain types of punctuation marks is new empirical data. It is fair to mention here a reviewer suggestion [58] encouraging investigations of the length distribution of symbol sequences commonly regarded as a 'unit of thought' or a proper sequence, that is not distinguishing between periods, semicolons, question and exclamation marks. However to test if such statistical measures can indeed be used to classify a text, e.g., to distinguish authorship, a much larger set of texts should be used. Similarly, from this single example the similarity between the Esperanto translation and the original text may not point to the quality of translation, since perhaps any natural text exhibit similar frequency distribution [58], and might be due to other external constraints, as hinted at the end of a previous paragraph.

Last but not least as on comparing AWLeng, AWLesp, and TLGeng, it seems that the texts are qualitatively similar, which indicates ... the quality of the translator. In this spirit, it would be interesting to compare with results originating from text obtained through a machine translation, as recently studied in [59]. It is of huge interest to see whether a machine is more flexible with vocabulary and grammar than a human translator, - see also [60]!

Finally, in summary, it is sufficient here to stress that punctuation marks are an essential part and a long lasting feature of indo-european languages, with a great variety of signs and in their use. At first sight, a time series of a single variable appears to provide a limited amount of information if texts and authorships. FTS and LTS result from a dynamical process, which is usually first characterized by its fractal dimension. The first approach should contain a mere statistical analysis of the output, as done through a Rank-like analysis here. It has been found that analytical forms, like power laws with different characteristic exponents for the ranking properties exist. The exponent can take values ca. 1.0, 0.50 or 0.30, depending on how a sentence is
defined. This non-universality, or even another law, could be further examined in order to find whether there is a measure of the author style hidden in such statistics/fits. Moreover one on-going challenge is to sort out the laws of sentence statistics in texts, written or produced by many authors, like scientific papers, thereby discriminating the percentage of truly personal contribution in the writing. Another apparently more simple investigation which is in direct line with previously mentioned studies [53] is the characterization of sentence statistics in online dynamic media, such as Blogs or RSS feeds, which are usually single author texts.

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