

# Short-Term Memory Capacity across Time and Language Estimated from Ancient and Modern Literary Texts. Study-Case: New Testament Translations

Emilio Matricciani

Dipartimento di Elettronica, Informazione e Bioingegneria (DEIB), Politecnico di Milano, Milan, Italy  
Email: emilio.matricciani@polimi.it

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## Abstract

We study the short-term memory capacity of ancient readers of the original New Testament written in Greek, of its translations to Latin and to modern languages. To model it, we consider the number of words between any two contiguous interpunctuations  $I_p$ , because this parameter can model how the human mind memorizes “chunks” of information. Since  $I_p$  can be calculated for any alphabetical text, we can perform experiments—otherwise impossible—with ancient readers by studying the literary works they used to read. The “experiments” compare the  $I_p$  of texts of a language/translation to those of another language/translation by measuring the minimum average probability of finding joint readers (those who can read both texts because of similar short-term memory capacity) and by defining an “overlap index”. We also define the population of universal readers, people who can read any New Testament text in any language. Future work is vast, with many research tracks, because alphabetical literatures are very large and allow many experiments, such as comparing authors, translations or even texts written by artificial intelligence tools.

## Keywords

Alphabetical Languages, Artificial Intelligence Writing, Greek, Latin, New Testament, Readers Overlap Probability, Short-Term Memory Capacity, Texts, Translation, Words Interval

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## 1. Short-Term Memory and Literary Texts

The aim of this paper is to study the short-term memory (STM) capacity of an-

cient readers of the Greek New Testament and its translations to Latin and to modern languages. For modelling the STM capacity, we consider the number of words between any two contiguous interpunctuations, termed “words interval” and indicated by  $I_p$  [1]-[6]. This parameter can reveal, as we show, whether the population of readers of given translation overlaps, as far as the STM capacity is concerned, with the population of readers of Greek and other languages. In other words, the study reveals how many translations a reader—supposed to be able to understand any language equally well—could read by engaging his/her STM.

The parameter  $I_p$  varies in the same range of the STM capacity, given by Miller’s  $7 \pm 2$  law [7], a range that includes 95% of all cases. For words, namely data that can be restricted (*i.e.*, “compressed”) by chunking, it seems that the average value in Miller’s range is not 7 but 5 to 6 [7].

As discussed in [1], very likely the two ranges are deeply related because interpunctuations organize small portions of more complex arguments (which make a sentence) in short chunks of text, which represent the natural STM input [8]-[19]. Moreover,  $I_p$ , drawn against the number of words per sentence,  $P_p$ , tends to approach a horizontal asymptote as  $P_p$  increases [1]-[6]. The writer, therefore, maybe unconsciously, introduces interpunctuations as sentences get longer because he/she acts also as a reader, therefore limiting  $I_p$  approximately in Miller’s range.

These findings can be explained, at least empirically, according to how our mind is thought to memorize “chunks” of information in the STM. When we start reading a sentence, our mind tries to predict its full meaning from what already read. Only when an interpunctuation is found our mind can better understand the meaning of the text. The longer and more twisted the sentence is, the longer the ideas remain deferred until the mind can establish its meaning from all its words (*i.e.*, from all the words interval contained in the sentence), with the result that the text is less readable. Readability, traditionally, is therefore measured mainly according to the length of sentences by any readability formula [20]-[29], neglecting the STM capacity required to read the sentence.

To overcome this shortcoming, in Reference [6] we have proposed a universal readability formula—applicable to any alphabetical language—which includes the STM capacity modeled by the word interval  $I_p$ .

By considering  $I_p$  we can perform experiments with ancient readers—otherwise impossible—by studying the literary works they used to read, for example the texts belonging to Greek and Latin Literatures. These “experiments” can reveal unexpected similarity and dependence between texts, because they consider four deep-language parameters [1]—two of which are  $P_p$  and  $I_p$ , being the other two number of characters per word,  $C_p$ , and the number of interpunctuations per sentence  $M_p$ —not consciously controlled by writers.

After this introduction, Section 2 reports the mean values of  $I_p$  for the languages/translations of the New Testament considered; Section 3 recalls and models the probability density function of  $I_p$ ; Section 4 discusses the probability of overlap and defines the overlap index; Section 5 defines the population of universal readers of the New Testament and Section 6 reports some final re-

marks and proposes future research work. **Appendix A** and **Appendix B** report the detailed numerical results used in the paper.

## 2. The New Testament from Greek to Latin and to Modern Languages

We study the statistical characteristics of  $I_p$  by considering a large selection of the New Testament (NT) books written in Greek—namely the Gospels according to *Matthew*, *Mark*, *Luke*, *John*, the Book of *Acts*, the *Epistle to the Romans*, the Book of *Revelation (Apocalypse)*, for a total of 155 chapters, according to the traditional subdivision of the original Greek texts—and their translation to Latin and 35 modern languages. A similar study could be done, of course, with other alphabetical texts.

The rationale for studying NT translations is based on its great importance for many scholars of multiple disciplines, besides the personal value for many readers. These translations, although are very rarely verbatim, strictly respect the subdivision in chapters and verses of the Greek texts—as they are fixed today, see Reference [30] for recalling how interpunctuations were introduced in the original *scriptio continua*—therefore they can be studied at least at these two different levels (chapters and verses), by comparing how a deep-language variable, like  $I_p$ , varies from translation to translation [3] [5]. Notice that in this paper “translation” is indistinguishable from “language”—because we deal only with one translation per language—but notice that language plays only one of the roles in translation, being the addressed audience another one [1]-[6]. A “real translation”—the one we always read—is never “ideal”, *i.e.* it never maintains all deep-language mathematical characteristics of the original text [2].

For our analysis, as done in References [3] [30], we have chosen the chapter level because the amount of text is sufficiently large to assess reliable statistics. Therefore, for each translation/language, we have considered a database of  $155 \times 37 = 5735$  samples of  $I_p$ , sufficiently large to give reliable statistical results.

Like in all our previous studies, samples were statistically weighted with the fraction of the total words, therefore in *Matthew* (28 chapters)—18,121 total words in Greek—each sample (chapter) does not weigh  $1/128 = 0.0078$  but the number of its words divided by the total words: Chapter 5, for example, is made of 824 words, therefore its weight is  $824/18,121 = 0.0455$ . This choice is mandatory to avoid that a short chapter (or, in general, a short text) affects the statistical results like a long one. After this processing we have obtained the mean values  $\langle m_{I_p} \rangle$ , and the standard deviation  $s_{I_p}$  reported in **Table 1** for the languages/translations considered—studied also in Reference [3] for other issues—subdivided in language families. Notice that in all languages the list of names reported in *Matthew* 1.1 - 1.17 and in *Luke* 3.23 - 3.38 (genealogy of Jesus of Nazareth) have been deleted for not biasing the statistics of linguistic variables [3].

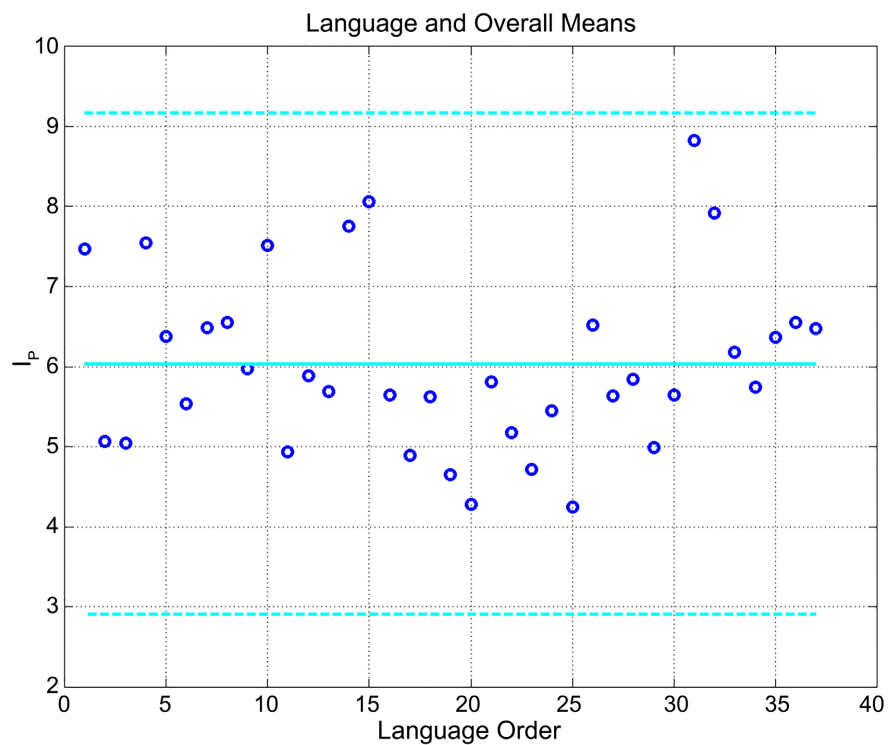
**Figure 1** shows the mean value and  $\pm 2$ -standard deviation bounds of  $I_p$ . At

**Table 1.** Mean value  $\langle m_{I_p} \rangle$  and standard deviation  $s_{I_p}$  of  $I_p$  for the indicated translation and language family of the New Testament books (*Matthew, Mark, Luke, John, Acts, Epistle to the Romans, Apocalypse*), calculated from 155 samples. Notice that the list of names reported in *Matthew* 1.1 - 1.17 17 and in *Luke* 3.23 - 3.38 (genealogy of Jesus of Nazareth) have been deleted for not biasing the statistics of linguistic variables [3]. Samples were statistically weighted with the fraction of the total words. The source of the texts considered is reported in Reference [3].

Language	Abbreviation	Order Number	Language Family	$m_{I_p}$	$s_{I_p}$
Greek	Gr	1	Hellenic	7.47	1.09
Latin	Lt	2	Italic	5.07	0.68
Esperanto	Es	3	Constructed	5.05	0.57
French	Fr	4	Romance	7.54	0.85
Italian	It	5	Romance	6.38	0.95
Portuguese	Pt	6	Romance	5.54	0.59
Romanian	Rm	7	Romance	6.49	0.74
Spanish	Sp	8	Romance	6.55	0.82
Danish	Dn	9	Germanic	5.97	0.64
English	En	10	Germanic	7.51	0.93
Finnish	Fn	11	Germanic	4.94	0.56
German	Ge	12	Germanic	5.89	0.60
Icelandic	Ic	13	Germanic	5.69	0.67
Norwegian	Nr	14	Germanic	7.75	0.84
Swedish	Sw	15	Germanic	8.06	1.35
Bulgarian	Bg	16	Balto-Slavic	5.64	0.64
Czech	Cz	17	Balto-Slavic	4.89	0.65
Croatian	Cr	18	Balto-Slavic	5.62	0.75
Polish	Pl	19	Balto-Slavic	4.65	0.43
Russian	Rs	20	Balto-Slavic	4.28	0.46
Serbian	Sr	21	Balto-Slavic	5.81	0.69
Slovak	Sl	22	Balto-Slavic	5.18	0.61
Ukrainian	Uk	23	Balto-Slavic	4.72	0.41
Estonian	Et	24	Uralic	5.45	0.66
Hungarian	Hn	25	Uralic	4.25	0.45
Albanian	Al	26	Albanian	6.52	0.78
Armenian	Ar	27	Armenian	5.63	0.52
Welsh	Wl	28	Celtic	5.84	0.44
Basque	Bs	29	Isolate	4.99	0.52
Hebrew	Hb	30	Semitic	5.65	0.59
Cebuano	Cb	31	Austronesian	8.82	1.01
Tagalog	Tg	32	Austronesian	7.92	0.82

## Continued

Chichewa	Ch	33	Niger-Congo	6.18	0.87
Luganda	Lg	34	Niger-Congo	5.74	0.82
Somali	Sm	35	Afro-Asiatic	6.37	1.01
Haitian	Ht	36	French Creole	6.55	0.71
Nahuatl	Nh	37	Uto-Aztecan	6.47	0.91



**Figure 1.** Mean value  $\langle m_{I_p} \rangle$  for the indicated language in abscissa, see **Table 1**. The continuous cyan refers to the overall mean value 6.03, the two cyan dashed lines to a  $\pm 2$ -standard deviations bounds (95% of the samples in Miller's range).

first glance, we can notice a large spread. However, all values are within Miller's range  $7 \pm 2$ .

The overall mean value is 6.03, close to 6.56 found in seven centuries of Italian Literature [1]—a further confirmation that  $I_p$  is centered about the mean value predicted when memorizing words [7]—and the overall standard deviation (*i.e.*, the square root of the sum of the mean variance and the variance of the mean [31]) is 1.56. Therefore, by considering 2 standard deviations (which correspond to consider 95% of the samples in Miller's range), we get  $6.03 \pm 2 \times 1.56$ , hence the range 2.91 - 9.15, reported in **Figure 1**. Notice, however, that the lower bound 2.91 is smaller than the value we should expect because—as we show in the next section—the probability density function of  $I_p$  is skewed to the right, it is not symmetrical.

For our analysis, directed to study and compare the STM capacity of ancient

and modern readers of the New Testament (study case), we need to recal, in the next section, how to model the probability density function of  $I_p$ .

### 3. Probability Density Function of $I_p$

Given the experimental mean value  $\langle m_{I_p} \rangle$  and standard deviation  $s_{I_p}$ , like those reported in **Table 1**, in Reference [1] we have shown that the experimental probability density function can be modelled with a log-normal with three parameters:

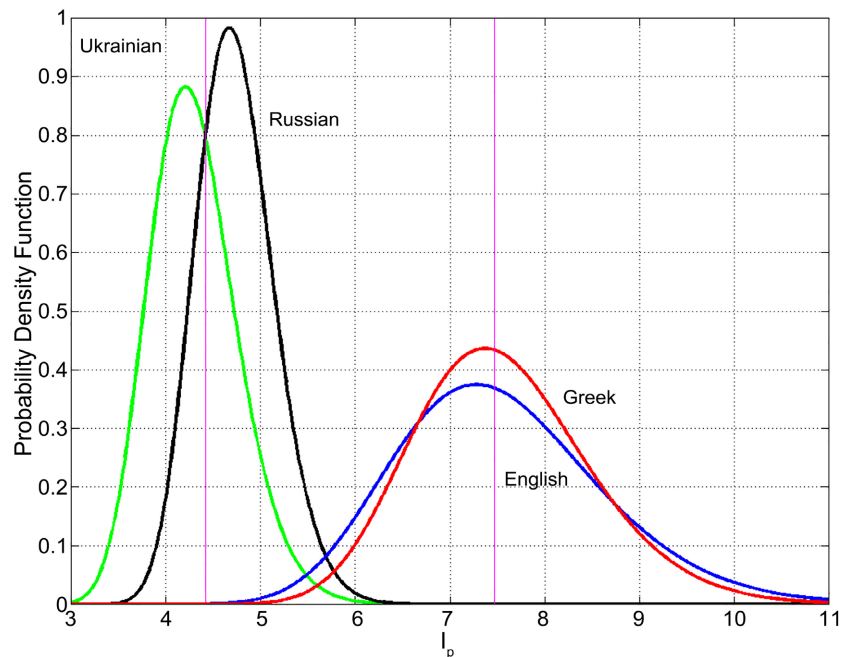
$$f(I_p) = \frac{1}{\sqrt{2\pi}\sigma_{I_p}(I_p - 1)} \exp\left\{-\frac{1}{2}\left[\frac{\log(I_p - 1) - \mu_{I_p}}{\sigma_{I_p}}\right]^2\right\}, \quad I_p \geq 1 \quad (1)$$

where the constants are given by [31]:

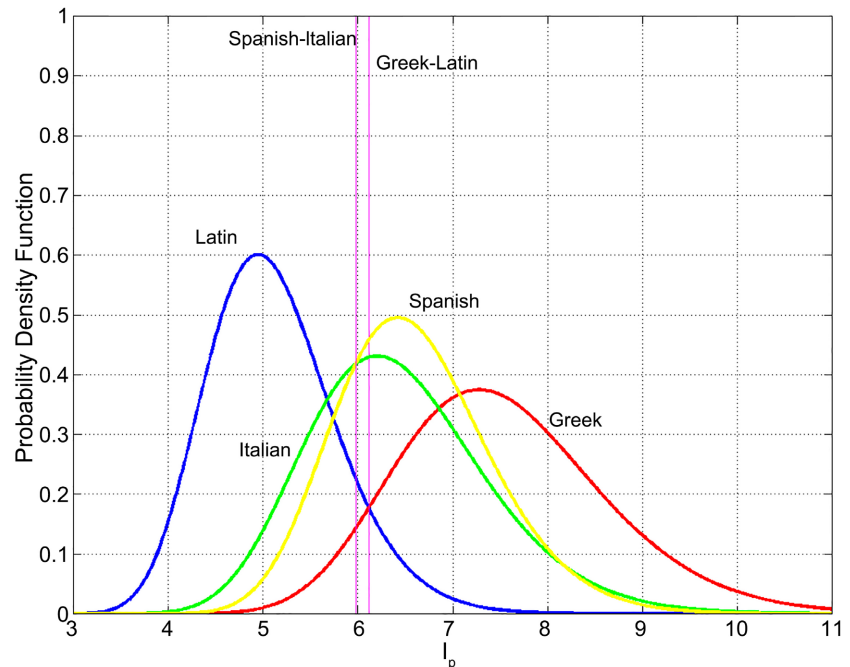
$$\sigma_{I_p}^2 = \log\left[\left(\frac{s_{I_p}}{\langle m_{I_p} \rangle - 1}\right)^2 + 1\right] \quad (2)$$

$$\mu_{I_p} = \log\left[\left(\langle m_{I_p} \rangle - 1\right) - \frac{\sigma_{I_p}^2}{2}\right] \quad (3)$$

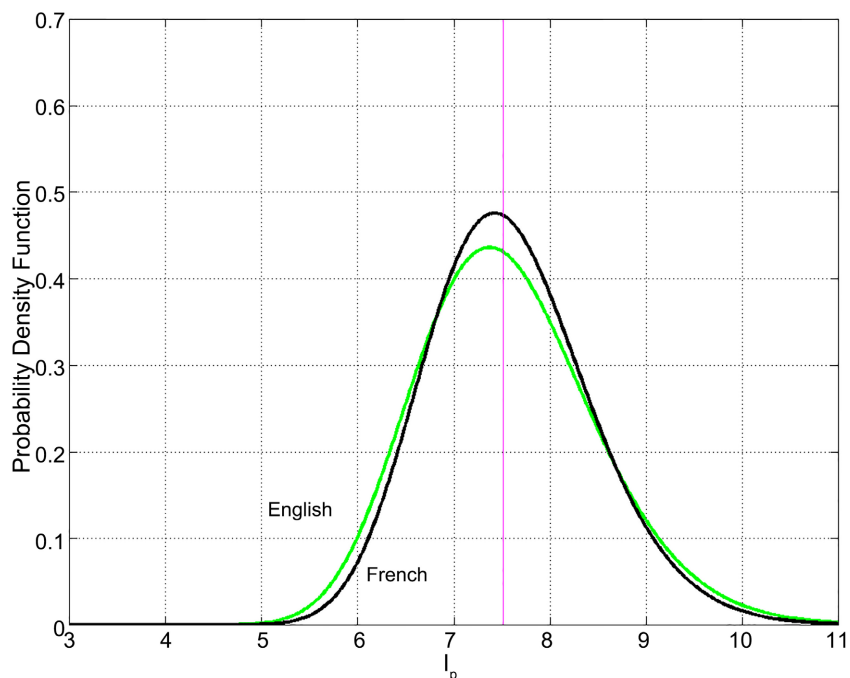
**Figures 2-4** show, as examples,  $f(I_p)$  for Ukrainian, Russian, Greek, English, Latin, Italian, Spanish, French. We can see that some densities can each other largely overlap, like Greek and English, or Italian and Spanish, while others overlap only slightly, like Ukrainian and Russian, Greek and Latin.



**Figure 2.** Probability density function  $f(I_p)$  for Ukrainian (green line), Russian (black line), Greek (red line), English (blue line). The vertical magenta lines give the thresholds to be used in Equation (4) for the indicated populations. Other thresholds can be drawn such as those between English and Russian or English and Ukrainian.



**Figure 3.** Probability density function  $f(I_p)$  for Latin (blue line), Italian (green line), Spanish (yellow line), Greek (red line). The vertical magenta lines give the thresholds to be used in Equation (4) for the indicated populations. Other thresholds can be drawn, such as those between Spanish and Latin, Spanish and Greek.



**Figure 4.** Probability density function  $f(I_p)$  for English (green line) and French (black line). The vertical magenta line gives the threshold to be used in Equation (4).

How can we compare the STM capacity of the readers of a language/translation to those of another language/translation? Since  $I_p$  seems to be a reliable estimate

of the STM capacity, then  $f(I_p)$  represents the probability density function that defines a population of readers according to their STM capacity. This is very important because we can do some experiments even with ancient readers by considering the texts they used to read.

In the next section, we propose a way of comparing probability density functions like those shown in **Figures 2-4**, by measuring the probability of overlap of readers (*i.e.*, readers who can read both texts) and by defining an “overlap index”.

#### 4. Probability of Readers' Overlap and Overlap Index

Let us assume that readers can read (and understand, of course) any alphabetical language. These readers represent mankind because we study their STM capacity through the word interval  $I_p$ . Can we “measure” how many readers of text  $j$  can potentially read text  $k$ , either written in the same language or in another language? What is the minimum percentage of readers who can read both, according to the probability density function of  $I_p$  of the two texts? We study this issue by first defining the minimum average probability of overlap and then the overlap index.

A mathematical analysis of a similar problem [3] shows that the minimum average probability of overlap  $p_o$  (%) between the populations of readers of text  $j$  and text  $k$  is given by:

$$p_o(\%) = 50 \left[ \int_{I_{p,\min}}^{\infty} g_j(I_p) dI_p + \int_{-\infty}^{I_{p,\min}} g_k(I_p) dI_p \right] \quad (4)$$

This probability is interpreted as the percentage of readers who can theoretically read both texts because they share the same STM capacity.

In Equation (4)  $g_j(I_p)$  and  $g_k(I_p)$  are the log-normal probability density functions of readers of text  $j$  and readers of text  $k$ , like those shown in **Figures 2-4**. The decision threshold  $I_{p,\min}$  is given by the intersection of  $g_j(I_p)$  and  $g_k(I_p)$ . The integral limits in Equation (4) assume  $\mu_j < \mu_k$ , as shown in **Figures 2-4** with the magenta lines, therefore,  $I_{p,\min} > \mu_j$ .

Let us study the range of  $p_o$ . If  $p_o = 0$ , there is no overlap between the two densities; their mean values are centered at  $-\infty$  and  $+\infty$ , respectively, or the two densities have collapsed to Dirac delta functions. In other words, the two populations of readers are disjoint (mutually exclusive). If  $p_o = 50\%$ , then the two densities are identical, *i.e.* text  $j$  and text  $k$  coincide (*e.g.*, it almost occurs in the cases of Greek versus English, Italian versus Spanish, or English versus French, see **Figures 2-4**). In conclusion:  $0 \leq p_o \leq 50\%$ , therefore, when  $p_o = 0$  the two populations of readers do not overlap; when  $p_o = 50\% = p_{o,\max}$ , the two populations fully overlap because  $g_j(I_p) = g_k(I_p)$ .

**Table A1** of **Appendix A** reports all values of  $p_o$  for the languages listed in **Table 1**. For example,  $p_o = 60.07\%$  for Ukrainian and Russia (**Figure 2**);  $p_o = 98.19\%$  for Greek and English (**Figure 2**);  $p_o = 16.31\%$  for Greek and Latin (**Figure 3**);  $p_o = 91.48\%$  for Italian and Spanish (**Figure 3**);  $p_o = 98.54\%$



for English and French (Figure 4). In other words, Greek and English readers, as well Italian and Spanish readers, can be confused because very likely they share the same STM capacity.

We define the overlap index  $I_o$  as:

$$I_o = \frac{P_o}{P_{o,\max}} \quad (5)$$

In Equation (5),  $0 \leq I_o \leq 1$ ;  $I_o = 0$  means non-overlapping (mutually exclusive) populations,  $I_o = 1$  means totally overlapping populations.

Figure 5 shows the probability distribution of exceeding a given  $I_o$ , calculated from Table A1. It seems that a uniform probability density function—given by the  $-1$  slope line—fits well the data. Notice that  $I_o > 0.9$  with probability 0.1 (10% of the cases).

According to the Theory of Communication [32], if a probability distribution is defined in the finite interval  $[a, b]$  ( $[0, 100]$  in our case) then the uniform distribution gives the maximum entropy supported in this interval. This seems to be the case for the overlap probability and the derived overlap index, as Figure 5 shows. In other words, the common subset of readers who can theoretically read both texts can assume any value between 0% and 100%.

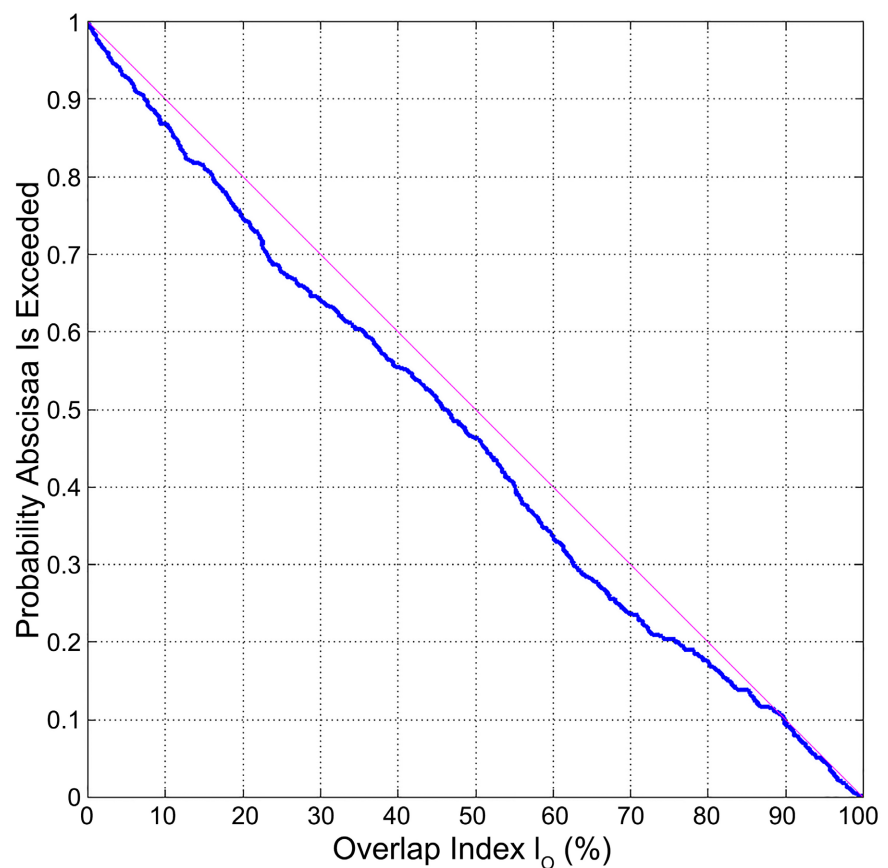


Figure 5. Probability distribution function of exceeding the overlap index  $I_o$  (%) in abscissa. The red line refers to a uniform distribution.

**Figure 6** shows the scatterplot of  $I_O$  calculated by comparing the population of Greek readers, assumed to be the reference population, to readers of all the other languages; or the readers of French (reference language) or English (reference language) to all the other languages.

In these examples it is evident the strong correlation between the values that assume Greek as reference language (scatterplot with red circles) and those that assume French (black circles) or English (green circles) as reference languages.

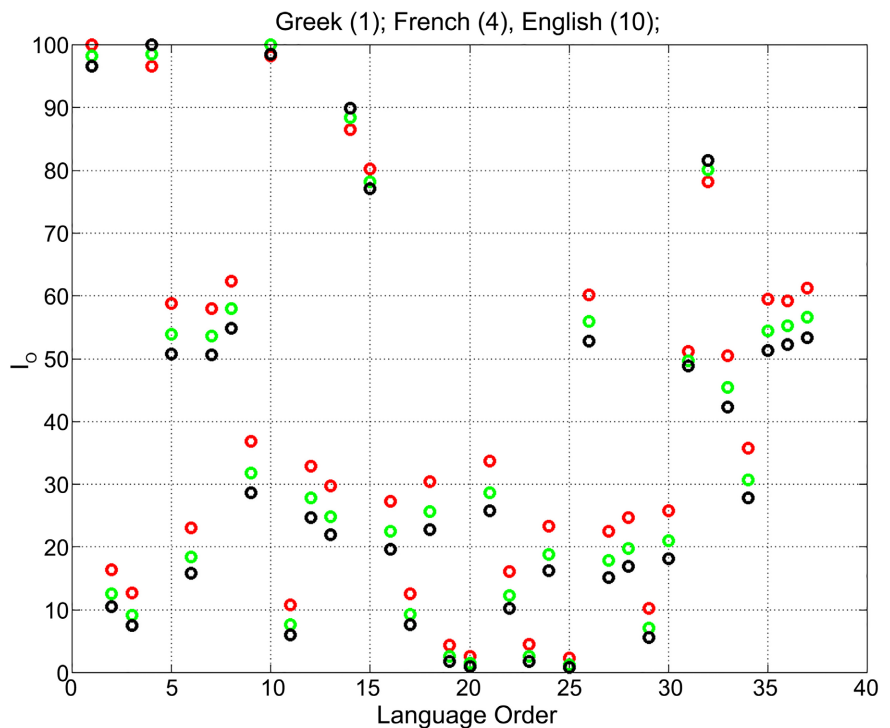
**Figure 7** shows the scatterplots and regression lines of  $I_p$  in two languages, for several cases. For example, Greek, French and English readers can be each other confused, while this is not possible with Greek and Spanish readers. **Table B1** of **Appendix B** reports all values of  $r_O$ .

An interesting parameter, linked to the correlation coefficient  $r_O$  is the coefficient of variation [29]:

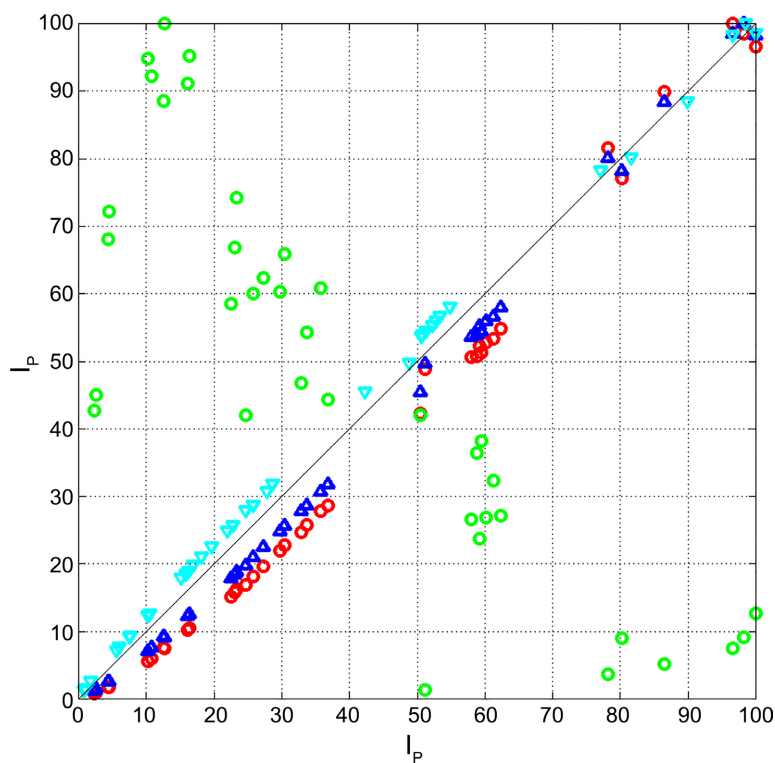
$$R = r_O^2 \tag{6}$$

The coefficient of variation  $R$  gives the fraction of the total variance of the dependent variable  $y$  accounted for by the regression line  $y = mx + q$ , and  $1 - R$  the proportion not accounted for. In other words, if  $r_O = \pm 1$ , then  $R = 1$ , the regression line tells all the story linking  $y$  to  $x$  because there is no scattering, hence the relationship between  $y$  and  $x$  is deterministic.

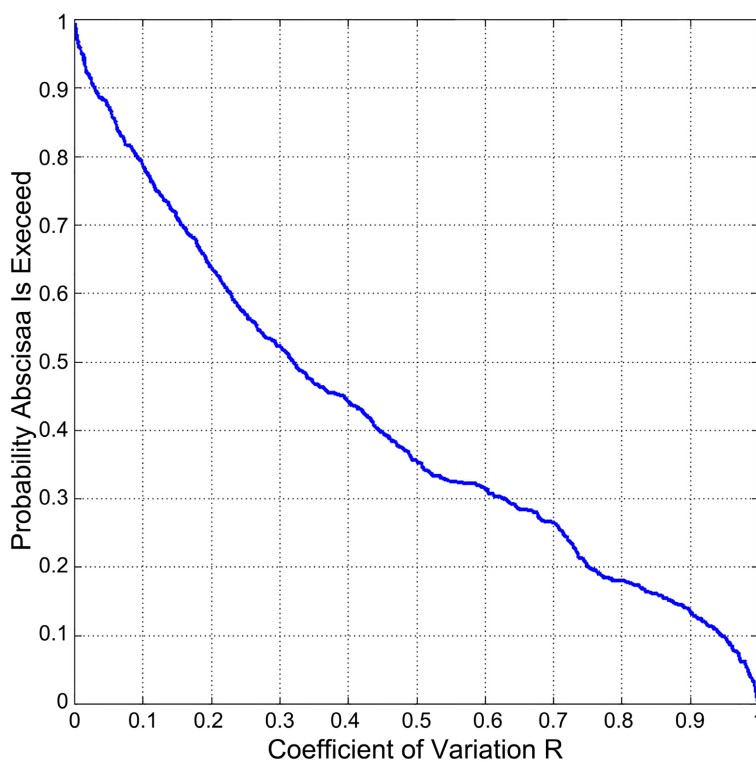
**Figure 8** shows the probability distribution function of exceeding a given value  $R$ . We can see that with probability less than 0.1 (10% of the cases)  $R > 0.95$ ,



**Figure 6.** Scatterplot of the overlap index  $I_O$  (%) versus language by assuming as reference language Greek (red circles), French (black circles) and English (Green circles).



**Figure 7.** Scatterplot of  $I_p$  and regression line of  $I_p$  in two languages, for several cases. French ( $y$ ) versus Greek ( $x$ ) (red circles), English versus Greek (blue upward triangles), English versus French (cyan downward triangles), Spanish versus Greek (green circles).



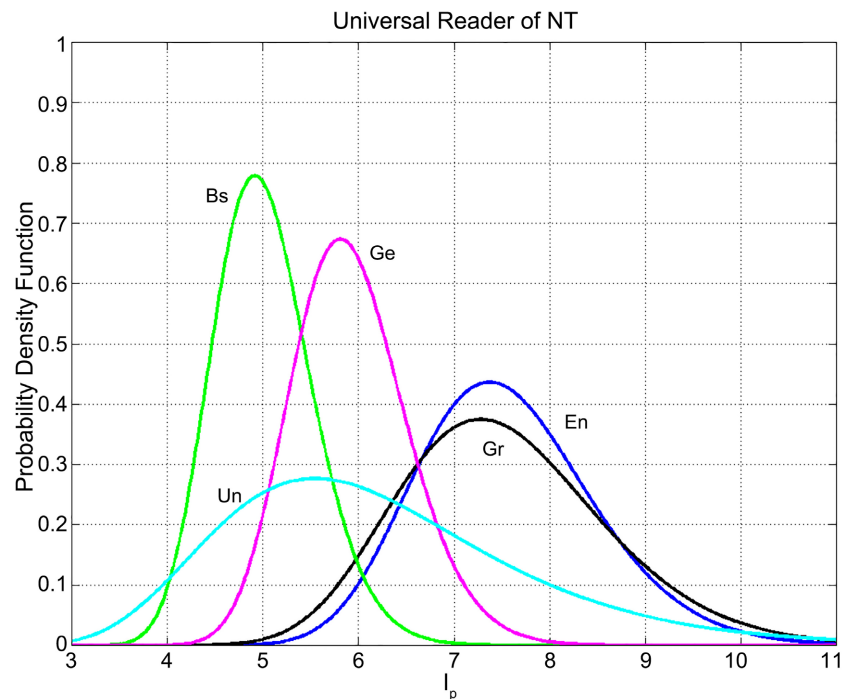
**Figure 8.** Probability distribution function of exceeding the coefficient of variation  $R$  in abscissa.

therefore for these latter cases 95% of the variance of the samples of  $y$  is due to the regression line linking it to  $x$ . **Table 2** lists, for example, some cases in which  $R > 0.95$  by reading in **Table B1 (Appendix B)** only the cases of positive correlation coefficients  $r_o = \sqrt{0.9500} = 0.9747$ . We can notice that belonging to a language family makes little difference, although some populations can be confused more than others, like in the cases of Italian and Spanish.

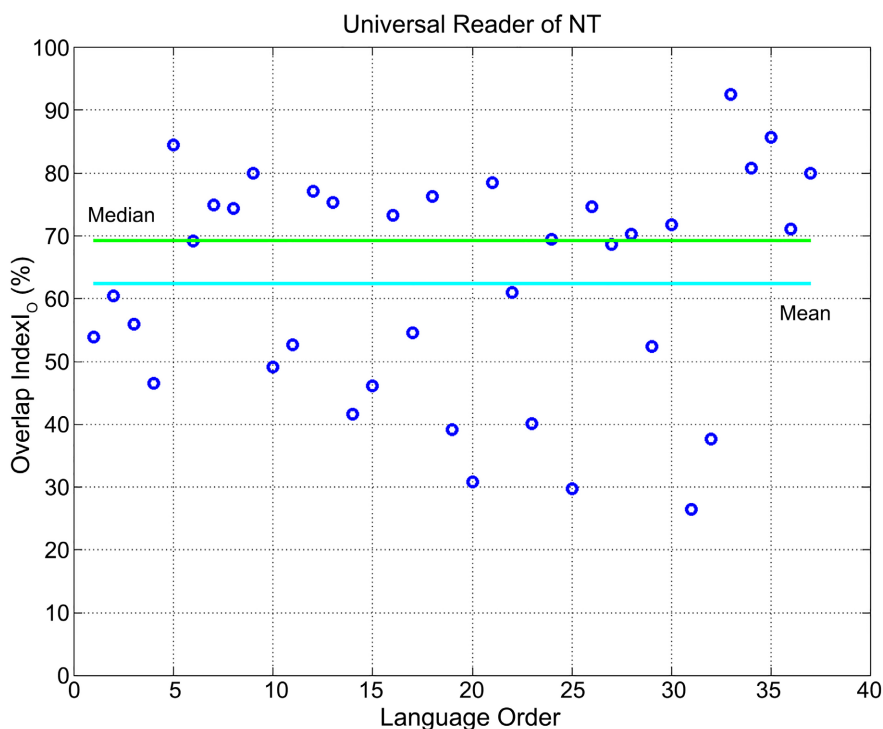
In the next section we define a “universal” reader of the New Testament.

**Table 2.** Reference language for which the coefficient of variation  $R > 0.95$ . Data taken from **Table B1 (Appendix B)** only in the cases of positive correlation coefficients  $r_o = \sqrt{0.9500} = 0.9747$ .

Reference Language	Languages with coefficient of variation $R > 0.95$
Greek	French, English
Latin	Esperanto, Finnish, Slovak
Esperanto	Latin, Finnish, Czech, Slovak, Basque
French	Greek, English, Norwegian
Italian	Romanian, Spanish, Albanian, Somali, Nahuatl
Spanish	Italian, Romanian, Albanian, Haitian, Nahuatl
English	Greek, French, Norwegian
German	Danish, Serbian, Welsh
Russian	Hungarian
Ukrainian	Polish



**Figure 9.** Probability density function  $f(I_p)$  for the Universal Reader (Un, cyan line), German (Ge, magenta line), English (En, blue line) and Greek (Gr, black line).



**Figure 10.** Overlap index  $I_o$  (%) of the probability density function  $f(I_p)$  of the languages in abscissa with the probability density function of the universal reader. The mean is 62.55%, the median is 69.20%.

## 5. Universal Reader of the New Testament

As mentioned in Section 2, the overall mean value of the data reported in **Table 1** is 6.03 and the overall standard deviation is 1.56. **Figure 9** shows the corresponding log-normal probability density function compared to that of some specific languages. This model can be considered as the probability density function of a population of “universal” readers who can read, as far as the STM capacity is concerned, any NT translation.

**Figure 10** shows the overlap index  $I_o$  (%) calculated by comparing the probability density function  $f(I_p)$  of the universal reader with the probability density function of the language in abscissa. More than 50% of the languages overlap with the universal reader with probability  $p_o > 69.20\%$ .

## 6. Final Remarks and Future Work

We have studied the short-term memory (STM) capacity of the ancient readers of the original New Testament written in Greek, and of readers of its translations to Latin and to modern languages. A similar study could be done with other alphabetical texts belonging to any literature.

For modelling the STM capacity, we have considered the number of words per interpunctuations, namely the “words interval”  $I_p$  because this parameter seems to describe how the human mind memorizes “chunks” of information in the STM.

Since  $I_p$  can be calculated for any alphabetical text, we can perform experi-

ments with ancient readers—otherwise impossible—by studying the literary works they used to read. These “experiments” can reveal unexpected similarity and dependence between texts, because they consider parameters not consciously controlled by writers, either ancient or modern.

The “experiments” done have compared the STM capacity of the readers of a language/translation to those of another language/translation, by measuring the probability of overlap of two languages/populations of readers and by defining an “overlap index”. For example, Greek and English readers, as well Italian and Spanish readers, can be confused because they practically share the same probability distribution of  $I_p$ . The detailed experimental values reported in large tables in **Appendix A** and **Appendix B** can give details on the other languages.

We have also defined a population of universal readers, namely readers who can read (and understand) the New Testament in any language. We have found that more than 50% of the languages overlap with the universal reader with probability  $p_o \gtrsim 70\%$ .

Future work is vast, with many research tracks, because alphabetical Literatures are very large and many experiments such as those reported in this paper can be done, according to specific purposes, such as comparing authors, translations or even texts written by artificial intelligence tools.

## Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

## References

- [1] Matricciani, E. (2019) Deep Language Statistics of Italian throughout Seven Centuries of Literature and Empirical Connections with Miller’s  $7 \mp 2$  Law and Short-Term Memory. *Open Journal of Statistics*, **9**, 373-406. <https://doi.org/10.4236/ojs.2019.93026>
- [2] Matricciani, E. (2020) A Statistical Theory of Language Translation Based on Communication Theory. *Open Journal of Statistics*, **10**, 936-997. <https://doi.org/10.4236/ojs.2020.106055>
- [3] Matricciani, E. (2022) Linguistic Mathematical Relationships Saved or Lost in Translating Texts: Extension of the Statistical Theory of Translation and Its Application to the New Testament. *Information*, **13**, Article 20. <https://doi.org/10.3390/info13010020>
- [4] Matricciani, E. (2022) Multiple Communication Channels in Literary Texts. *Open Journal of Statistics*, **12**, 486-520. <https://doi.org/10.4236/ojs.2022.124030>
- [5] Matricciani, E. (2023) Capacity of Linguistic Communication Channels in Literary Texts: Application to Charles Dickens’ Novels. *Information*, **14**, Article 68. <https://doi.org/10.3390/info14020068>
- [6] Matricciani, E. (2023) Readability Indices Do Not Say It All on a Text Readability. *Analytics*, **2**, 296-314. <https://doi.org/10.3390/analytics2020016>
- [7] Miller, G.A. (1955) The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information. *Psychological Review*, **101**, 343-352.

- <https://doi.org/10.1037/0033-295X.101.2.343>
- [8] Baddeley, A.D., Thomson, N. and Buchanan, M. (1975) Word Length and the Structure of Short-Term Memory. *Journal of Verbal Learning and Verbal Behavior*, **14**, 575-589. [https://doi.org/10.1016/S0022-5371\(75\)80045-4](https://doi.org/10.1016/S0022-5371(75)80045-4)
- [9] Cowan, N. (2000) The Magical Number 4 in Short-Term Memory: A Reconsideration of Mental Storage Capacity. *Behavioral and Brain Sciences*, **24**, 87-114. <https://doi.org/10.1017/S0140525X01003922>
- [10] Pothos, E.M. and Jola, P. (2000) Linguistic Structure and Short-Term Memory. *Behavioral and Brain Sciences*, **24**, 138-139. <https://doi.org/10.1017/S0140525X01463928>
- [11] Jones, G. and Macken, B. (2015) Questioning Short-Term Memory and Its Measurements: Why Digit Span Measures Long-Term Associative Learning. *Cognition*, **144**, 1-13. <https://doi.org/10.1016/j.cognition.2015.07.009>
- [12] Saaty, T.L. and Ozdemir, M.S. (2003) Why the Magic Number Seven plus or Minus Two. *Mathematical and Computer Modelling*, **38**, 233-244. [https://doi.org/10.1016/S0895-7177\(03\)90083-5](https://doi.org/10.1016/S0895-7177(03)90083-5)
- [13] Mathy, F. and Feldman, J. (2012) What's Magic about Magic Numbers? Chunking and Data Compression in Short-Term Memory. *Cognition*, **122**, 346-362. <https://doi.org/10.1016/j.cognition.2011.11.003>
- [14] Chen, Z. and Cowan, N. (2005) Chunk Limits and Length Limits in Immediate Recall: A Reconciliation. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **31**, 1235-1249. <https://doi.org/10.1037/0278-7393.31.6.1235>
- [15] Chekaf, M., Cowan, N. and Mathy, F. (2016) Chunk Formation in Immediate Memory and How It Relates to Data Compression. *Cognition*, **155**, 96-107. <https://doi.org/10.1016/j.cognition.2016.05.024>
- [16] Barrouillest, P. and Camos, V. (2012) As Time Goes By: Temporal Constraints in Working Memory. *Current Directions in Psychological Science*, **21**, 413-419. <https://doi.org/10.1177/0963721412459513>
- [17] Conway, A.R.A., Cowan, N., Michael, F., Bunting, M.F., Theriault, D.J. and Minkoff, S.R.B. (2002) A Latent Variable Analysis of Working Memory Capacity, Short-Term Memory Capacity, Processing Speed, and General Fluid Intelligence. *Intelligence*, **30**, 163-183. [https://doi.org/10.1016/S0160-2896\(01\)00096-4](https://doi.org/10.1016/S0160-2896(01)00096-4)
- [18] Islam, M., Sarkar, A., Hossain, M., Ahmed, M. and Ferdous, A. (2023) Prediction of Attention and Short-Term Memory Loss by EEG Workload Estimation. *Journal of Biosciences and Medicines*, **11**, 304-318. <https://doi.org/10.4236/jbm.2023.114022>
- [19] Hayashi, K. and Takahashi, N. (2020) The Relationship between Phonological Short-Term Memory and Vocabulary Acquisition in Japanese Young Children. *Open Journal of Modern Linguistics*, **10**, 132-160. <https://doi.org/10.4236/ojml.2020.102009>
- [20] Flesch, R. (1948) A New Readability Yardstick. *Journal of Applied Psychology*, **32**, 222-233. <https://doi.org/10.1037/h0057532>
- [21] Flesch, R. (1974) *The Art of Readable Writing*. Harper & Row, New York.
- [22] Kincaid, J.P., Fishburne, R.P., Rogers, R.L. and Chissom, B.S. (1975) Derivation of New Readability Formulas (Automated Readability Index, Fog Count and Flesch Reading Ease Formula) for Navy Enlisted Personnel. Research Branch Report 8-75, Chief of Naval Technical Training, Naval Air Station, Memphis.
- [23] DuBay, W.H. (2004) *The Principles of Readability*. Impact Information, Costa Mesa.

- [24] Bailin, A. and Graftstein, A. (2001) The Linguistic Assumptions Underlying Readability Formulae: A Critique. *Language & Communication*, **21**, 285-301. [https://doi.org/10.1016/S0271-5309\(01\)00005-2](https://doi.org/10.1016/S0271-5309(01)00005-2)
- [25] DuBay, W.H. (2006) The Classic Readability Studies. Impact Information, Costa Mesa.
- [26] Zamanian, M. and Heydari, P. (2012) Readability of Texts: State of the Art. *Theory and Practice in Language Studies*, **2**, 43-53. <https://doi.org/10.4304/tpls.2.1.43-53>
- [27] Benjamin, R.G. (2012) Reconstructing Readability: Recent Developments and Recommendations in the Analysis of Text Difficulty. *Educational Psychology Review*, **24**, 63-88. <https://doi.org/10.1007/s10648-011-9181-8>
- [28] Collins-Thompson, K. (2014) Computational Assessment of Text Readability: A Survey of Current and Future Research. *ITL—International Journal of Applied Linguistics*, **165**, 97-135. <https://doi.org/10.1075/itl.165.2.01col>
- [29] Kandel, L. and Moles, A. (1958) Application de l'indice de Flesch à la langue française. *Cahiers Etudes de Radio-Télévision*, **19**, 253-274.
- [30] Matricciani, E. and Caro, L.D. (2019) A Deep-Language Mathematical Analysis of Gospels, Acts and Revelation. *Religions*, **10**, Article 257. <https://doi.org/10.3390/rel10040257>
- [31] Papoulis, A. (1990) Probability & Statistics. Prentice Hall, Hoboken.
- [32] Shannon, C.E. (1948) A Mathematical Theory of Communication. *The Bell System Technical Journal*, **27**, 623-656. <https://doi.org/10.1002/j.1538-7305.1948.tb00917.x>



## Appendix A. Values of the Probability of Overlap $p_o$

**Table A1.** Values of the probability of overlap  $p_o$  (%) for the indicated languages. The languages indicated in the first row are the reference languages, then languages indicated in the first column are the dependent languages. For example, if Greek is the reference language, the Latin overlaps for 16.31% of the readers, French overlaps for 96.56%. Of course, symmetry is due to the definition of  $p_o$ .

	Gr	Lt	Es	Fr	It	Pt	Rm	Sp	Dn	En
Gr	100.00	16.31	12.66	96.56	58.84	23.03	57.97	62.30	36.79	98.19
Lt	16.31	100.00	95.26	10.57	41.23	69.34	31.32	31.84	48.60	12.54
Es	12.66	95.26	100.00	7.46	36.49	66.88	26.60	27.14	44.30	9.20
Fr	96.56	10.57	7.46	100.00	50.74	15.79	50.58	54.87	28.61	98.54
It	58.84	41.23	36.49	50.74	100.00	56.64	93.84	91.48	76.75	53.94
Pt	23.03	69.34	66.88	15.79	56.64	100.00	47.04	46.59	72.49	18.38
Rm	57.97	31.32	26.60	50.58	93.84	47.04	100.00	95.67	70.40	53.68
Sp	62.30	31.84	27.14	54.87	91.48	46.59	95.67	100.00	68.50	57.99
Dn	36.79	48.60	44.30	28.61	76.75	72.49	70.40	68.50	100.00	31.73
En	98.19	12.54	9.20	98.54	53.94	18.38	53.68	57.99	31.73	100.00
Fn	10.74	89.96	92.16	6.06	32.29	59.77	22.73	23.40	38.66	7.60
Ge	32.85	50.89	46.84	24.75	71.98	76.59	65.03	63.30	94.55	27.80
Ic	29.70	63.80	60.24	21.93	65.82	89.90	56.70	55.97	82.42	24.78
Nr	86.46	7.86	5.23	89.90	43.39	11.69	42.18	46.51	22.40	88.43
Sw	80.17	12.03	9.06	77.02	45.51	16.30	42.80	46.88	26.33	78.22
Bg	27.33	65.51	62.28	19.71	62.71	93.15	53.45	52.79	79.30	22.49
Cz	12.58	89.12	88.49	7.66	34.07	58.72	24.65	25.32	39.59	9.30
Cr	30.44	69.70	65.90	22.79	64.96	91.64	55.19	54.88	78.20	25.59
Pl	4.37	67.93	68.10	1.80	18.12	37.58	10.42	11.21	20.83	2.56
Rs	2.65	47.75	44.96	1.01	11.49	22.50	5.92	6.59	11.94	1.47
Sr	33.73	58.20	54.23	25.72	71.58	82.84	63.11	62.07	89.84	28.71
Sl	16.12	92.58	91.09	10.19	42.83	75.76	32.72	33.08	52.26	12.23
Uk	4.49	70.99	72.13	1.83	19.03	40.34	11.01	11.80	22.29	2.61
Et	23.35	76.91	74.25	16.27	55.32	93.75	45.33	45.21	68.21	18.79
Hn	2.37	45.63	42.74	0.87	10.64	20.93	5.33	5.97	10.92	1.29
Al	60.19	31.60	26.89	52.79	92.60	46.83	97.77	97.89	69.46	55.90
Ar	22.57	61.19	58.47	15.19	57.57	92.95	48.59	47.74	76.32	17.85
Wl	24.69	45.83	41.96	16.86	62.64	73.75	55.66	53.81	85.25	19.75
Bs	10.27	90.71	94.85	5.62	32.28	61.76	22.59	23.22	39.37	7.14
Hb	25.77	63.11	60.05	18.19	61.35	92.45	52.33	51.52	79.35	20.95
Cb	51.11	2.58	1.41	48.80	21.27	3.48	17.75	21.16	7.72	49.60
Tg	78.23	5.95	3.73	81.52	37.57	8.78	35.64	39.92	17.80	80.11

## Continued

Ch	50.47	46.73	42.03	42.28	91.01	64.59	83.05	81.77	85.73	45.47
Lg	35.72	65.10	60.84	27.83	71.44	85.19	61.72	61.38	85.35	30.76
Sm	59.43	43.00	38.26	51.26	99.53	57.83	93.25	90.95	76.82	54.46
Ht	59.27	28.38	23.70	52.23	90.15	43.32	96.57	96.64	66.54	55.25
Nh	61.29	37.06	32.33	53.38	95.95	52.11	98.80	95.99	72.93	56.58
	Fn	Ge	Ic	Nr	Sw	Bg	Cz	Cr	Pl	Rs
Gr	10.74	32.85	29.70	86.46	80.17	27.33	12.58	30.44	4.37	2.65
Lt	89.96	50.89	63.80	7.86	12.03	65.51	89.12	69.70	67.93	47.75
Es	92.16	46.84	60.24	5.23	9.06	62.28	88.49	65.90	68.10	44.96
Fr	6.06	24.75	21.93	89.90	77.02	19.71	7.66	22.79	1.80	1.01
It	32.29	71.98	65.82	43.39	45.51	62.71	34.07	64.96	18.12	11.49
Pt	59.77	76.59	89.90	11.69	16.30	93.15	58.72	91.64	37.58	22.50
Rm	22.73	65.03	56.70	42.18	42.80	53.45	24.65	55.19	10.42	5.92
Sp	23.40	63.30	55.97	46.51	46.88	52.79	25.32	54.88	11.21	6.59
Dn	38.66	94.55	82.42	22.40	26.33	79.30	39.59	78.20	20.83	11.94
En	7.60	27.80	24.78	88.43	78.22	22.49	9.30	25.59	2.56	1.47
Fn	100.00	40.86	53.80	4.19	7.70	55.60	96.26	59.68	75.91	51.31
Ge	40.86	100.00	86.50	18.99	23.24	83.25	41.51	81.86	22.17	12.55
Ic	53.80	86.50	100.00	16.95	21.49	96.70	53.76	95.69	33.23	20.33
Nr	4.19	18.99	16.95	100.00	82.31	15.01	5.55	17.98	1.08	0.60
Sw	7.70	23.24	21.49	82.31	100.00	19.61	9.28	22.54	3.08	1.95
Bg	55.60	83.25	96.70	15.01	19.61	100.00	55.26	98.64	34.47	20.90
Cz	96.26	41.51	53.76	5.55	9.28	55.26	100.00	59.75	78.77	57.34
Cr	59.68	81.86	95.69	17.98	22.54	98.64	59.75	100.00	39.16	25.38
Pl	75.91	22.17	33.23	1.08	3.08	34.47	78.77	39.16	100.00	66.82
Rs	51.31	12.55	20.33	0.60	1.95	20.90	57.34	25.38	66.82	100.00
Sr	48.17	94.54	92.92	20.19	24.51	89.69	48.62	88.76	28.71	17.40
Sl	83.62	55.08	68.76	7.39	11.60	70.96	80.78	74.16	60.00	39.35
Uk	79.92	23.81	35.44	1.08	3.13	36.85	81.57	41.42	93.08	60.07
Et	67.30	71.53	85.46	12.31	16.92	87.94	66.25	89.83	45.06	28.69
Hn	48.96	11.47	18.92	0.51	1.75	19.45	55.06	23.84	64.14	97.32
Al	23.08	64.17	56.35	44.40	44.88	53.14	25.00	55.06	10.82	6.26
Ar	51.45	81.30	91.75	10.97	15.59	94.79	50.76	99.01	29.86	16.72
Wl	35.80	90.51	86.18	11.98	16.57	81.84	36.36	80.04	17.17	8.69
Bs	96.06	41.80	55.12	3.79	7.26	57.13	92.03	60.82	71.67	46.44
Hb	53.25	83.85	95.53	13.60	18.21	99.27	52.80	97.80	32.00	18.75
Cb	1.09	6.10	5.84	55.98	71.04	4.92	1.72	6.80	0.19	0.12

## Continued

Tg	2.94	14.79	13.31	91.63	85.71	11.62	4.10	14.40	0.65	0.37
Ch	37.29	80.96	74.18	35.37	38.33	70.96	38.80	72.67	21.46	13.49
Lg	55.10	89.70	93.84	22.51	26.89	91.04	55.74	93.47	35.83	23.53
Sm	34.10	72.26	66.76	44.15	46.56	63.73	35.88	66.19	19.83	12.90
Ht	20.07	61.16	52.90	43.53	43.52	49.67	22.04	51.54	8.65	4.81
Nh	28.33	67.97	61.36	45.61	47.00	58.22	30.19	60.42	15.01	9.26
	Sr	Sl	Uk	Et	Hn	Al	Ar	Wl	Bs	Hb
Gr	33.73	16.12	4.49	23.35	2.37	60.19	22.57	24.69	10.27	25.77
Lt	58.20	92.58	70.99	76.91	45.63	31.60	61.19	45.83	90.71	63.11
Es	54.23	91.09	72.13	74.25	42.74	26.89	58.47	41.96	94.85	60.05
Fr	25.72	10.19	1.83	16.27	0.87	52.79	15.19	16.86	5.62	18.19
It	71.58	42.83	19.03	55.32	10.64	92.60	57.57	62.64	32.28	61.35
Pt	82.84	75.76	40.34	93.75	20.93	46.83	92.95	73.75	61.76	92.45
Rm	63.11	32.72	11.01	45.33	5.33	97.77	48.59	55.66	22.59	52.33
Sp	62.07	33.08	11.80	45.21	5.97	97.89	47.74	53.81	23.22	51.52
Dn	89.84	52.26	22.29	68.21	10.92	69.46	76.32	85.25	39.37	79.35
En	28.71	12.23	2.61	18.79	1.29	55.90	17.85	19.75	7.14	20.95
Fn	48.17	83.62	79.92	67.30	48.96	23.08	51.45	35.80	96.06	53.25
Ge	94.54	55.08	23.81	71.53	11.47	64.17	81.30	90.51	41.80	83.85
Ic	92.92	68.76	35.44	85.46	18.92	56.35	91.75	86.18	55.12	95.53
Nr	20.19	7.39	1.08	12.31	0.51	44.40	10.97	11.98	3.79	13.60
Sw	24.51	11.60	3.13	16.92	1.75	44.88	15.59	16.57	7.26	18.21
Bg	89.69	70.96	36.85	87.94	19.45	53.14	94.79	81.84	57.13	99.27
Cz	48.62	80.78	81.57	66.25	55.06	25.00	50.76	36.36	92.03	52.80
Cr	88.76	74.16	41.42	89.83	23.84	55.06	99.01	80.04	60.82	97.80
Pl	28.71	60.00	93.08	45.06	64.14	10.82	29.86	17.17	71.67	32.00
Rs	17.40	39.35	60.07	28.69	97.32	6.26	16.72	8.69	46.44	18.75
Sr	100.00	62.48	30.60	78.74	16.14	62.62	85.45	97.05	49.18	89.10
Sl	62.48	100.00	63.59	83.03	37.29	32.92	67.33	50.44	86.00	68.82
Uk	30.60	63.59	100.00	47.90	57.43	11.42	32.33	18.72	76.30	34.38
Et	78.74	83.03	47.90	100.00	26.98	45.29	85.95	67.30	69.11	86.25
Hn	16.14	37.29	57.43	26.98	100.00	5.66	15.36	7.78	44.12	17.35
Al	62.62	32.92	11.42	45.29	5.66	100.00	48.17	54.72	22.93	51.94
Ar	85.45	67.33	32.33	85.95	15.36	48.17	100.00	81.09	53.34	96.22
Wl	97.05	50.44	18.72	67.30	7.78	54.72	81.09	100.00	36.88	82.74
Bs	49.18	86.00	76.30	69.11	44.12	22.93	53.34	36.88	100.00	54.90
Hb	89.10	68.82	34.38	86.25	17.35	51.94	96.22	82.74	54.90	100.00

## Continued

Cb	7.25	2.18	0.18	4.06	0.10	19.46	2.92	2.83	0.91	4.13
Tg	16.09	5.44	0.64	9.46	0.31	37.83	8.04	8.61	2.60	10.32
Ch	80.30	48.99	22.62	62.67	12.50	82.38	65.98	71.58	37.51	69.75
Lg	95.78	68.66	37.76	83.44	22.11	61.58	85.83	90.54	55.90	89.51
Sm	72.24	44.52	20.77	56.72	12.00	92.04	58.53	63.08	34.08	62.29
Ht	59.25	29.56	9.14	41.77	4.30	98.25	44.76	51.81	19.86	48.51
Nh	67.26	38.49	15.78	50.79	8.51	97.32	53.11	58.53	28.25	56.89

	Cb	Tg	Ch	Lg	Sm	Ht	Nh
Gr	51.11	78.23	50.47	35.72	59.43	59.27	61.29
Lt	2.58	5.95	46.73	65.10	43.00	28.38	37.06
Es	1.41	3.73	42.03	60.84	38.26	23.70	32.33
Fr	48.80	81.52	42.28	27.83	51.26	52.23	53.38
It	21.27	37.57	91.01	71.44	99.53	90.15	95.95
Pt	3.48	8.78	64.59	85.19	57.83	43.32	52.11
Rm	17.75	35.64	83.05	61.72	93.25	96.57	98.80
Sp	21.16	39.92	81.77	61.38	90.95	99.93	95.99
Dn	7.72	17.80	85.73	85.35	76.82	66.54	72.93
En	49.60	80.11	45.47	30.76	54.46	55.25	56.58
Fn	1.09	2.94	37.29	55.10	34.10	20.07	28.33
Ge	6.10	14.79	80.96	89.70	72.26	61.16	67.97
Ic	5.84	13.31	74.18	93.84	66.76	52.90	61.36
Nr	55.98	91.63	35.37	22.51	44.15	43.53	45.61
Sw	71.04	85.71	38.33	26.89	46.56	43.52	47.00
Bg	4.92	11.62	70.96	91.04	63.73	49.67	58.22
Cz	1.72	4.10	38.80	55.74	35.88	22.04	30.19
Cr	6.80	14.40	72.67	93.47	66.19	51.54	60.42
Pl	0.19	0.65	21.46	35.83	19.83	8.65	15.01
Rs	0.12	0.37	13.49	23.53	12.90	4.81	9.26
Sr	7.25	16.09	80.30	95.78	72.24	59.25	67.26
Sl	2.18	5.44	48.99	68.66	44.52	29.56	38.49
Uk	0.18	0.64	22.62	37.76	20.77	9.14	15.78
Et	4.06	9.46	62.67	83.44	56.72	41.77	50.79
Hn	0.10	0.31	12.50	22.11	12.00	4.30	8.51
Al	19.46	37.83	82.38	61.58	92.04	98.25	97.32
Ar	2.92	8.04	65.98	85.83	58.53	44.76	53.11
Wl	2.83	8.61	71.58	90.54	63.08	51.81	58.53
Bs	0.91	2.60	37.51	55.90	34.08	19.86	28.25

## Continued

Hb	4.13	10.32	69.75	89.51	62.29	48.51	56.89
Cb	100.00	61.90	15.98	9.30	22.49	18.00	21.96
Tg	61.90	100.00	29.99	18.49	38.50	36.74	39.45
Ch	15.98	29.99	100.00	79.19	90.97	79.16	86.92
Lg	9.30	18.49	79.19	100.00	72.60	58.06	66.91
Sm	22.49	38.50	90.97	72.60	100.00	89.54	95.46
Ht	18.00	36.74	79.16	58.06	89.54	100.00	95.32
Nh	21.96	39.45	86.92	66.91	95.46	95.32	100.00

Appendix B. Values of the Correlation Coefficient  $r_o$ 

**Table B1.** Values of the correlation coefficient  $r_o$  (%) for the indicated languages. The languages indicated in the first row are the reference languages, the languages indicated in the first column are the dependent languages. For example, if Greek is the reference language, then the correlation coefficient is  $r_o = -0.8352$  with Latin,  $r_o = 0.9941$  with French. Of course, symmetry is due to the definition of  $r_o$ .

	Gr	Lt	Es	Fr	It	Pt	Rm	Sp	Dn	En
Gr	1	-0.8352	-0.8386	0.9941	0.4374	-0.5187	0.5240	0.5771	-0.0602	0.9978
Lt	-0.8352	1	0.9973	-0.8487	-0.2255	0.7017	-0.3402	-0.3864	0.2315	-0.8448
Es	-0.8386	0.9973	1	-0.8470	-0.2717	0.6674	-0.3831	-0.4275	0.1814	-0.8451
Fr	0.9941	-0.8487	-0.8470	1	0.3453	-0.5862	0.4386	0.4950	-0.1559	0.9991
It	0.4374	-0.2255	-0.2717	0.3453	1	0.3335	0.9862	0.9761	0.7899	0.3818
Pt	-0.5187	0.7017	0.6674	-0.5862	0.3335	1	0.1987	0.1498	0.7920	-0.5615
Rm	0.5240	-0.3402	-0.3831	0.4386	0.9862	0.1987	1	0.9970	0.6986	0.4728
Sp	0.5771	-0.3864	-0.4275	0.4950	0.9761	0.1498	0.9970	1	0.6608	0.5281
Dn	-0.0602	0.2315	0.1814	-0.1559	0.7899	0.7920	0.6986	0.6608	1	-0.1193
En	0.9978	-0.8448	-0.8451	0.9991	0.3818	-0.5615	0.4728	0.5281	-0.1193	1
Fn	-0.8592	0.9771	0.9859	-0.8556	-0.3722	0.5591	-0.4714	-0.5134	0.0561	-0.8581
Ge	-0.1579	0.3190	0.2706	-0.2498	0.7074	0.8549	0.6041	0.5628	0.9904	-0.2148
Ic	-0.3732	0.5508	0.5087	-0.4531	0.5039	0.9713	0.3776	0.3310	0.9035	-0.4233
Nr	0.9687	-0.8623	-0.8545	0.9860	0.2374	-0.6471	0.3335	0.3922	-0.2542	0.9801
Sw	0.9514	-0.8646	-0.8575	0.9606	0.2512	-0.6239	0.3415	0.3985	-0.2281	0.9575
Bg	-0.4219	0.5990	0.5594	-0.4976	0.4448	0.9863	0.3152	0.2679	0.8675	-0.4695
Cz	-0.8710	0.9692	0.9768	-0.8657	-0.3846	0.5374	-0.4809	-0.5235	0.0381	-0.8688
Cr	-0.4435	0.6297	0.5907	-0.5180	0.4283	0.9899	0.2972	0.2494	0.8523	-0.4904
Pl	-0.8577	0.8227	0.8412	-0.8247	-0.5903	0.2596	-0.6518	-0.6864	-0.2426	-0.8381
Rs	-0.7832	0.5903	0.6043	-0.7356	-0.6610	0.0261	-0.6872	-0.7162	-0.3988	-0.7540
Sr	-0.2472	0.4160	0.3696	-0.3350	0.6307	0.9086	0.5165	0.4725	0.9659	-0.3019
Sl	-0.7971	0.9848	0.9759	-0.8228	-0.1182	0.8034	-0.2435	-0.2914	0.3609	-0.8143
Uk	-0.8581	0.8563	0.8749	-0.8291	-0.5633	0.3077	-0.6315	-0.6667	-0.2018	-0.8411

## Continued

Et	-0.6056	0.8036	0.7740	-0.6650	0.2335	0.9859	0.0963	0.0462	0.7075	-0.6435
Hn	-0.7709	0.5690	0.5830	-0.7224	-0.6629	0.0071	-0.6861	-0.7143	-0.4095	-0.7411
Al	0.5502	-0.3641	-0.4060	0.4665	0.9808	0.1721	0.9991	0.9992	0.6778	0.5002
Ar	-0.4282	0.5932	0.5545	-0.5023	0.4241	0.9864	0.2945	0.2475	0.8573	-0.4749
Wl	-0.2169	0.3516	0.3049	-0.3043	0.6347	0.8781	0.5256	0.4829	0.9670	-0.2713
Bs	-0.8490	0.9861	0.9941	-0.8493	-0.3409	0.5978	-0.4447	-0.4871	0.0970	-0.8504
Hb	-0.4112	0.5816	0.5418	-0.4873	0.4512	0.9831	0.3226	0.2757	0.8734	-0.4591
Cb	0.7771	-0.8187	-0.7973	0.8051	-0.0266	-0.7117	0.0639	0.1191	-0.4371	0.7943
Tg	0.9391	-0.8632	-0.8513	0.9625	0.1635	-0.6809	0.2603	0.3199	-0.3164	0.9539
Ch	0.2185	-0.0048	-0.0554	0.1197	0.9541	0.5737	0.8987	0.8746	0.9310	0.1582
Lg	-0.3202	0.5091	0.4645	-0.4047	0.5711	0.9459	0.4485	0.4026	0.9362	-0.3729
Sm	0.4301	-0.2130	-0.2593	0.3376	0.9999	0.3453	0.9838	0.9732	0.7956	0.3742
Ht	0.5704	-0.3921	-0.4329	0.4890	0.9715	0.1348	0.9966	0.9992	0.6492	0.5219
Nh	0.5142	-0.3138	-0.3573	0.4270	0.9920	0.2322	0.9988	0.9951	0.7203	0.4618
	Fn	Ge	Ic	Nr	Sw	Bg	Cz	Cr	Pl	Rs
Gr	-0.8592	-0.1579	-0.3732	0.9687	0.9514	-0.4219	-0.8710	-0.4435	-0.8577	-0.7832
Lt	0.9771	0.3190	0.5508	-0.8623	-0.8646	0.5990	0.9692	0.6297	0.8227	0.5903
Es	0.9859	0.2706	0.5087	-0.8545	-0.8575	0.5594	0.9768	0.5907	0.8412	0.6043
Fr	-0.8556	-0.2498	-0.4531	0.9860	0.9606	-0.4976	-0.8657	-0.5180	-0.8247	-0.7356
It	-0.3722	0.7074	0.5039	0.2374	0.2512	0.4448	-0.3846	0.4283	-0.5903	-0.6610
Pt	0.5591	0.8549	0.9713	-0.6471	-0.6239	0.9863	0.5374	0.9899	0.2596	0.0261
Rm	-0.4714	0.6041	0.3776	0.3335	0.3415	0.3152	-0.4809	0.2972	-0.6518	-0.6872
Sp	-0.5134	0.5628	0.3310	0.3922	0.3985	0.2679	-0.5235	0.2494	-0.6864	-0.7162
Dn	0.0561	0.9904	0.9035	-0.2542	-0.2281	0.8675	0.0381	0.8523	-0.2426	-0.3988
En	-0.8581	-0.2148	-0.4233	0.9801	0.9575	-0.4695	-0.8688	-0.4904	-0.8381	-0.7540
Fn	1	0.1451	0.3893	-0.8531	-0.8621	0.4430	0.9976	0.4770	0.9094	0.6947
Ge	0.1451	1	0.9472	-0.3410	-0.3135	0.9186	0.1262	0.9050	-0.1591	-0.3291
Ic	0.3893	0.9472	1	-0.5285	-0.5026	0.9960	0.3685	0.9919	0.0800	-0.1304
Nr	-0.8531	-0.3410	-0.5285	1	0.9809	-0.5677	-0.8635	-0.5880	-0.7989	-0.7014
Sw	-0.8621	-0.3135	-0.5026	0.9809	1	-0.5423	-0.8748	-0.5646	-0.8228	-0.7343
Bg	0.4430	0.9186	0.9960	-0.5677	-0.5423	1	0.4218	0.9983	0.1366	-0.0805
Cz	0.9976	0.1262	0.3685	-0.8635	-0.8748	0.4218	1	0.4564	0.9272	0.7316
Cr	0.4770	0.9050	0.9919	-0.5880	-0.5646	0.9983	0.4564	1	0.1726	-0.0493
Pl	0.9094	-0.1591	0.0800	-0.7989	-0.8228	0.1366	0.9272	0.1726	1	0.8799
Rs	0.6947	-0.3291	-0.1304	-0.7014	-0.7343	-0.0805	0.7316	-0.0493	0.8799	1
Sr	0.2457	0.9907	0.9786	-0.4208	-0.3940	0.9581	0.2260	0.9480	-0.0633	-0.2519
Sl	0.9312	0.4479	0.6686	-0.8456	-0.8411	0.7128	0.9171	0.7390	0.7298	0.4782

## Continued

Uk	0.9354	-0.1167	0.1266	-0.8057	-0.8270	0.1837	0.9485	0.2198	0.9952	0.8417
Et	0.6784	0.7778	0.9267	-0.7192	-0.7005	0.9499	0.6582	0.9604	0.3938	0.1475
Hn	0.6747	-0.3414	-0.1468	-0.6875	-0.7209	-0.0978	0.7125	-0.0671	0.8658	0.9993
Al	-0.4928	0.5813	0.3520	0.3625	0.3695	0.2893	-0.5025	0.2710	-0.6688	-0.7008
Ar	0.4377	0.9112	0.9919	-0.5690	-0.5421	0.9979	0.4158	0.9965	0.1321	-0.0828
Wl	0.1807	0.9907	0.9619	-0.3872	-0.3571	0.9371	0.1616	0.9234	-0.1198	-0.2880
Bs	0.9974	0.1867	0.4304	-0.8492	-0.8556	0.4835	0.9911	0.5165	0.8832	0.6544
Hb	0.4242	0.9239	0.9964	-0.5573	-0.5310	0.9996	0.4028	0.9969	0.1174	-0.0964
Cb	-0.7776	-0.4984	-0.6358	0.8641	0.9126	-0.6594	-0.7894	-0.6806	-0.6845	-0.5815
Tg	-0.8436	-0.3977	-0.5731	0.9926	0.9854	-0.6084	-0.8541	-0.6286	-0.7747	-0.6726
Ch	-0.1723	0.8780	0.7228	0.0104	0.0305	0.6721	-0.1877	0.6567	-0.4406	-0.5588
Lg	0.3441	0.9703	0.9929	-0.4872	-0.4623	0.9805	0.3244	0.9755	0.0333	-0.1724
Sm	-0.3609	0.7143	0.5141	0.2295	0.2439	0.4556	-0.3737	0.4395	-0.5830	-0.6584
Ht	-0.5158	0.5500	0.3159	0.3861	0.3913	0.2527	-0.5246	0.2343	-0.6802	-0.7024
Nh	-0.4499	0.6285	0.4087	0.3215	0.3315	0.3473	-0.4610	0.3298	-0.6437	-0.6926
	Sr	Sl	Uk	Et	Hn	Al	Ar	Wl	Bs	Hb
Gr	-0.2472	-0.7971	-0.8581	-0.6056	-0.7709	0.5502	-0.4282	-0.2169	-0.8490	-0.4112
Lt	0.4160	0.9848	0.8563	0.8036	0.5690	-0.3641	0.5932	0.3516	0.9861	0.5816
Es	0.3696	0.9759	0.8749	0.7740	0.5830	-0.4060	0.5545	0.3049	0.9941	0.5418
Fr	-0.3350	-0.8228	-0.8291	-0.6650	-0.7224	0.4665	-0.5023	-0.3043	-0.8493	-0.4873
It	0.6307	-0.1182	-0.5633	0.2335	-0.6629	0.9808	0.4241	0.6347	-0.3409	0.4512
Pt	0.9086	0.8034	0.3077	0.9859	0.0071	0.1721	0.9864	0.8781	0.5978	0.9831
Rm	0.5165	-0.2435	-0.6315	0.0963	-0.6861	0.9991	0.2945	0.5256	-0.4447	0.3226
Sp	0.4725	-0.2914	-0.6667	0.0462	-0.7143	0.9992	0.2475	0.4829	-0.4871	0.2757
Dn	0.9659	0.3609	-0.2018	0.7075	-0.4095	0.6778	0.8573	0.9670	0.0970	0.8734
En	-0.3019	-0.8143	-0.8411	-0.6435	-0.7411	0.5002	-0.4749	-0.2713	-0.8504	-0.4591
Fn	0.2457	0.9312	0.9354	0.6784	0.6747	-0.4928	0.4377	0.1807	0.9974	0.4242
Ge	0.9907	0.4479	-0.1167	0.7778	-0.3414	0.5813	0.9112	0.9907	0.1867	0.9239
Ic	0.9786	0.6686	0.1266	0.9267	-0.1468	0.3520	0.9919	0.9619	0.4304	0.9964
Nr	-0.4208	-0.8456	-0.8057	-0.7192	-0.6875	0.3625	-0.5690	-0.3872	-0.8492	-0.5573
Sw	-0.3940	-0.8411	-0.8270	-0.7005	-0.7209	0.3695	-0.5421	-0.3571	-0.8556	-0.5310
Bg	0.9581	0.7128	0.1837	0.9499	-0.0978	0.2893	0.9979	0.9371	0.4835	0.9996
Cz	0.2260	0.9171	0.9485	0.6582	0.7125	-0.5025	0.4158	0.1616	0.9911	0.4028
Cr	0.9480	0.7390	0.2198	0.9604	-0.0671	0.2710	0.9965	0.9234	0.5165	0.9969
Pl	-0.0633	0.7298	0.9952	0.3938	0.8658	-0.6688	0.1321	-0.1198	0.8832	0.1174
Rs	-0.2519	0.4782	0.8417	0.1475	0.9993	-0.7008	-0.0828	-0.2880	0.6544	-0.0964
Sr	1	0.5411	-0.0187	0.8441	-0.2661	0.4922	0.9515	0.9951	0.2873	0.9615

## Continued

Sl	0.5411	1	0.7703	0.8865	0.4561	-0.2686	0.7085	0.4802	0.9496	0.6976
Uk	-0.0187	0.7703	1	0.4415	0.8257	-0.6488	0.1791	-0.0780	0.9134	0.1643
Et	0.8441	0.8865	0.4415	1	0.1270	0.0693	0.9482	0.8024	0.7130	0.9428
Hn	-0.2661	0.4561	0.8257	0.1270	1	-0.6993	-0.0998	-0.3005	0.6335	-0.1133
Al	0.4922	-0.2686	-0.6488	0.0693	-0.6993	1	0.2687	0.5020	-0.4665	0.2969
Ar	0.9515	0.7085	0.1791	0.9482	-0.0998	0.2687	1	0.9327	0.4787	0.9985
Wl	0.9951	0.4802	-0.0780	0.8024	-0.3005	0.5020	0.9327	1	0.2221	0.9427
Bs	0.2873	0.9496	0.9134	0.7130	0.6335	-0.4665	0.4787	0.2221	1	0.4652
Hb	0.9615	0.6976	0.1643	0.9428	-0.1133	0.2969	0.9985	0.9427	0.4652	1
Cb	-0.5606	-0.8194	-0.6945	-0.7661	-0.5677	0.0910	-0.6501	-0.5169	-0.7775	-0.6481
Tg	-0.4732	-0.8526	-0.7830	-0.7479	-0.6585	0.2897	-0.6072	-0.4376	-0.8412	-0.5978
Ch	0.8236	0.1170	-0.4054	0.4792	-0.5653	0.8853	0.6541	0.8233	-0.1352	0.6777
Lg	0.9926	0.6273	0.0795	0.8972	-0.1882	0.4232	0.9733	0.9785	0.3847	0.9810
Sm	0.6391	-0.1050	-0.5551	0.2463	-0.6606	0.9781	0.4348	0.6421	-0.3291	0.4618
Ht	0.4586	-0.3002	-0.6623	0.0321	-0.7001	0.9989	0.2321	0.4695	-0.4909	0.2604
Nh	0.5440	-0.2134	-0.6206	0.1304	-0.6924	0.9972	0.3266	0.5512	-0.4213	0.3544

	Cb	Tg	Ch	Lg	Sm	Ht	Nh
Gr	0.7771	0.9391	0.2185	-0.3202	0.4301	0.5704	0.5142
Lt	-0.8187	-0.8632	-0.0048	0.5091	-0.2130	-0.3921	-0.3138
Es	-0.7973	-0.8513	-0.0554	0.4645	-0.2593	-0.4329	-0.3573
Fr	0.8051	0.9625	0.1197	-0.4047	0.3376	0.4890	0.4270
It	-0.0266	0.1635	0.9541	0.5711	0.9999	0.9715	0.9920
Pt	-0.7117	-0.6809	0.5737	0.9459	0.3453	0.1348	0.2322
Rm	0.0639	0.2603	0.8987	0.4485	0.9838	0.9966	0.9988
Sp	0.1191	0.3199	0.8746	0.4026	0.9732	0.9992	0.9951
Dn	-0.4371	-0.3164	0.9310	0.9362	0.7956	0.6492	0.7203
En	0.7943	0.9539	0.1582	-0.3729	0.3742	0.5219	0.4618
Fn	-0.7776	-0.8436	-0.1723	0.3441	-0.3609	-0.5158	-0.4499
Ge	-0.4984	-0.3977	0.8780	0.9703	0.7143	0.5500	0.6285
Ic	-0.6358	-0.5731	0.7228	0.9929	0.5141	0.3159	0.4087
Nr	0.8641	0.9926	0.0104	-0.4872	0.2295	0.3861	0.3215
Sw	0.9126	0.9854	0.0305	-0.4623	0.2439	0.3913	0.3315
Bg	-0.6594	-0.6084	0.6721	0.9805	0.4556	0.2527	0.3473
Cz	-0.7894	-0.8541	-0.1877	0.3244	-0.3737	-0.5246	-0.4610
Cr	-0.6806	-0.6286	0.6567	0.9755	0.4395	0.2343	0.3298
Pl	-0.6845	-0.7747	-0.4406	0.0333	-0.5830	-0.6802	-0.6437
Rs	-0.5815	-0.6726	-0.5588	-0.1724	-0.6584	-0.7024	-0.6926



## Continued

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Sr	-0.5606	-0.4732	0.8236	0.9926	0.6391	0.4586	0.5440
Sl	-0.8194	-0.8526	0.1170	0.6273	-0.1050	-0.3002	-0.2134
Uk	-0.6945	-0.7830	-0.4054	0.0795	-0.5551	-0.6623	-0.6206
Et	-0.7661	-0.7479	0.4792	0.8972	0.2463	0.0321	0.1304
Hn	-0.5677	-0.6585	-0.5653	-0.1882	-0.6606	-0.7001	-0.6924
Al	0.0910	0.2897	0.8853	0.4232	0.9781	0.9989	0.9972
Ar	-0.6501	-0.6072	0.6541	0.9733	0.4348	0.2321	0.3266
Wl	-0.5169	-0.4376	0.8233	0.9785	0.6421	0.4695	0.5512
Bs	-0.7775	-0.8412	-0.1352	0.3847	-0.3291	-0.4909	-0.4213
Hb	-0.6481	-0.5978	0.6777	0.9810	0.4618	0.2604	0.3544
Cb	1	0.9012	-0.2304	-0.6170	-0.0340	0.1138	0.0522
Tg	0.9012	1	-0.0621	-0.5370	0.1557	0.3137	0.2482
Ch	-0.2304	-0.0621	1	0.7778	0.9571	0.8655	0.9138
Lg	-0.6170	-0.5370	0.7778	1	0.5808	0.3879	0.4786
Sm	-0.0340	0.1557	0.9571	0.5808	1	0.9683	0.9903
Ht	0.1138	0.3137	0.8655	0.3879	0.9683	1	0.9929
Nh	0.0522	0.2482	0.9138	0.4786	0.9903	0.9929	1

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