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Keywords: Alphabetical Languages; Artificial Intelligence Writing; Greek; Latin; New Testament; Readers Overlap Probability; Short–Term Memory Capacity, Texts; Translation; Word Interval

*Article*

# Short–Term Memory Capacity Across Time and Language Estimated from Ancient and Modern Literary Texts

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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 modern languages. To model the short–term capacity, we have considered the number of words per interpunctions, the "word interval" $I_p$, 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 their similar short–-term memory capacity) and by defining an "overlap index". We also define a population of universal readers who can read any the New Testament written in alphabetical language. More than 50% of the readers of specific languages overlap with the universal readers with probability $p_O \gtrsim 70\%$. 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; word 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 the ancient readers of the New Testament written in Greek, in transalations to Latin and modern languages. For modelling the STM capacity, we consider the number of words per interpunctions, termed "word interval" and indicated by $I_p$ [1–6]. This parameter can reveal, as we show, whether the population of readers of a 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 will reveal how many translations a reader – supposed to be able to understand any language equally well − could read by engaging his/her STM.

The deep–language 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 interpunctions organize small portions of more complex arguments (which make a sentence) in short chunks of text, which represent the natural STM input [8–17]. Moreover, $I_p$, drawn against the number of words per sentence, $P_F$, tends to approach a horizontal asymptote as $P_F$ increases [1–6]. The writer, unconsciously, introduces interpunctions as sentences get longer because he/she acts also as a reader, therefore limits $I_p$ approximately in Miller's range.

These findings can be explained, at least empirically, according to the way 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, as it can be concluded from experiments. Only

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when an interpunction 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 word intervals 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 [18–27], neglecting the STM capacity required for reading 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 measured 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 the 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 $P_F$ and $I_P$, being the other two the number of characters per word, $C_P$, and the number on interpunctions per sentence $M_F$ − not consciously controlled by writers.

After this introduction, Section 2 reports the statistical 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 defines and discusses the probability of overlap and the overlap index; Section 5 defines the population of universal readers of the New Testament and Section 6 reports some final remarks and proposes future research work. Appendices A and B report the detailed numerical results used in the paper.

## 2. Translations of New Testament from Greek to Latin and 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, altough are very rarely verbatim, strictly respect the subdivision in chapters and verses of the Greek texts – as they are fixed today, see Reference [28] for recalling how interpunctions where 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 indistingushable 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 [3,28], 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. The languages/translations considered are listed in Table 1 – studied also in Reference [3] for other issues − subdivided in language families, together with the mean value $m_{I_P}$, and standard deviation $s_{I_P}$ of $I_P$. 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].

**Table 1.** Mean value $m_{I_P}$ 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*

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3.23–3.38 (genealogy of Jesus of Nazareth) have been deleted for not biasing the statistics of linguistic variables [3]. 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 |
| 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 |

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Figure 1 shows the mean value and $\pm 2$–standard deviation bounds of $I_P$. At first glance, we can notice a large spread, however, all values are within Miller's range $7 \pm 2$.

The global 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 [29]) 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 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 $I_P$.

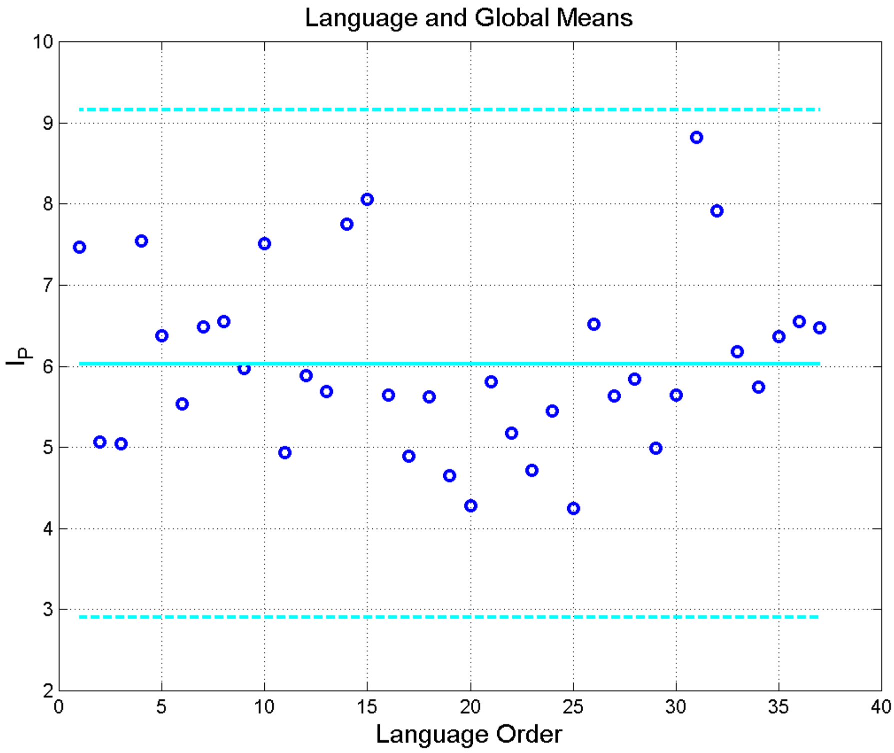


**Figure 1.** Mean value $m_{I_P}$ for the indicated language in abscissa, from Table 1. The continuous cyan refers to the global mean value 6.03, the two cyan dashed lines to a $\pm 2$–standard deviations bounds (95% of the samples in Miller's range).

### 3. Probability density function of $I_P$

Given the experimental mean value $m_{I_P}$ and standard deviation $s_{I_P}$ of $I_P$, 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 model with three parameters:

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

where the constants are given by [29]:

$$\sigma_{I_P}^2 = \log\left[\left(\frac{s_{I_P}}{m_{I_P}-1}\right)^2 + 1\right] \qquad (2)$$

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

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.

How can we compare the STM 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 (who can read both texts) and by defining an "overlap index".

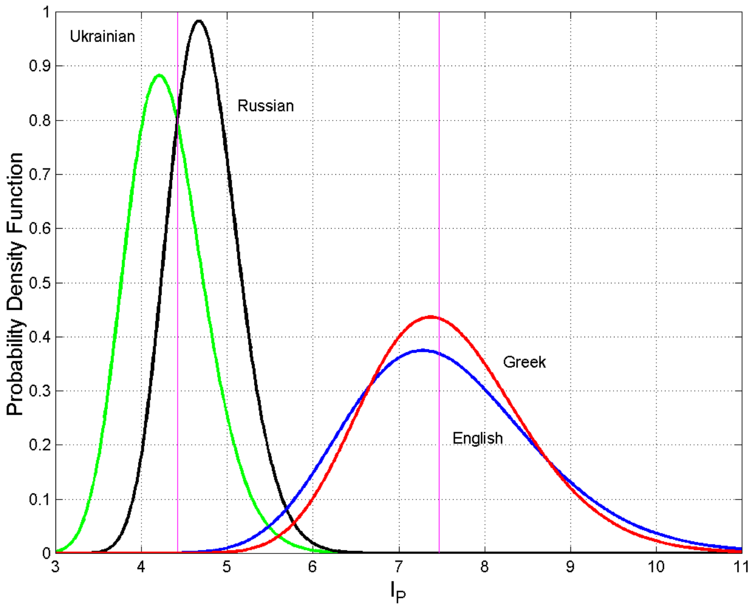


**Figure 2.** Probability density function $f(I_P)$ for Ukrainian (green line), Russian (black line), Greek (red line), English (blue line). The vertical magenta lines give the thresholds to be used in Equation (4) for the indicated populations. Other thresholds can be drawn such as those between English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

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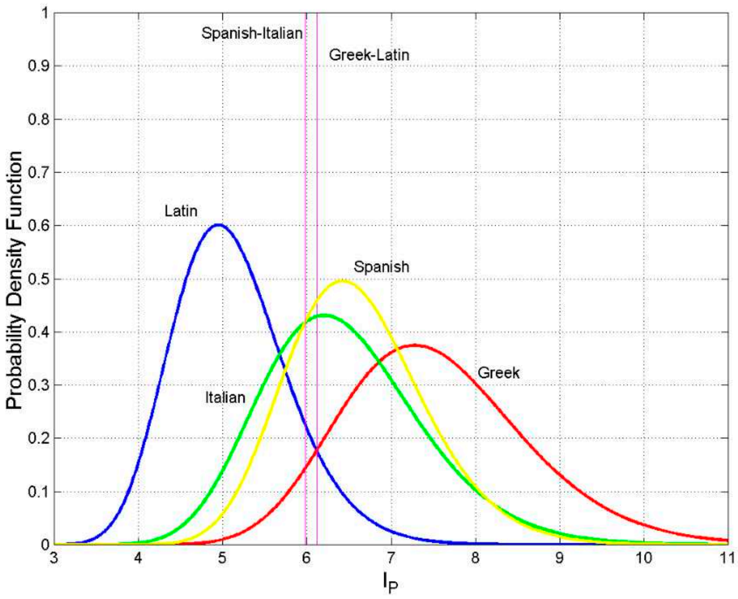


**Figure 3.** Probability density function $f(I_P)$ for Latin (blue line), Italian (green line), Spanish (yellow line), Greek (red line). The vertical magenta lines give the thresholds to be used in Equation (4) for the indicated populations. Other thresholds can be drawn, such as those between Spanish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

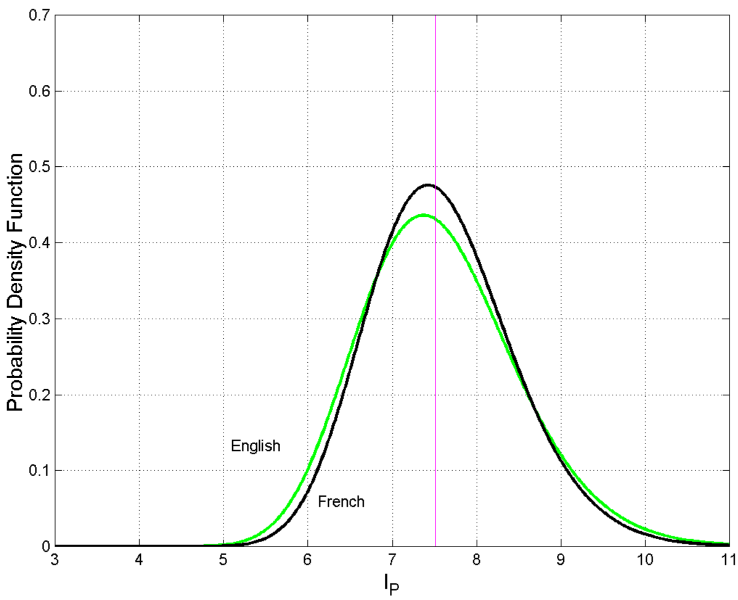


**Figure 4.** Probability density function $f(I_P)$ for English (green line) and French (black line). The vertical magenta line gives the threshold to be used in Equation (4).

## 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: $0 \le p_O \le 50$, 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 etc., can be confused because 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), $0 \le I_O \le 1$; $I_O = 0$ 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 fits well the data. Notice that $I_O > 0.9$ with probability 0.1 (10% of the cases).

According to the Theory of Communication [30], 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%.

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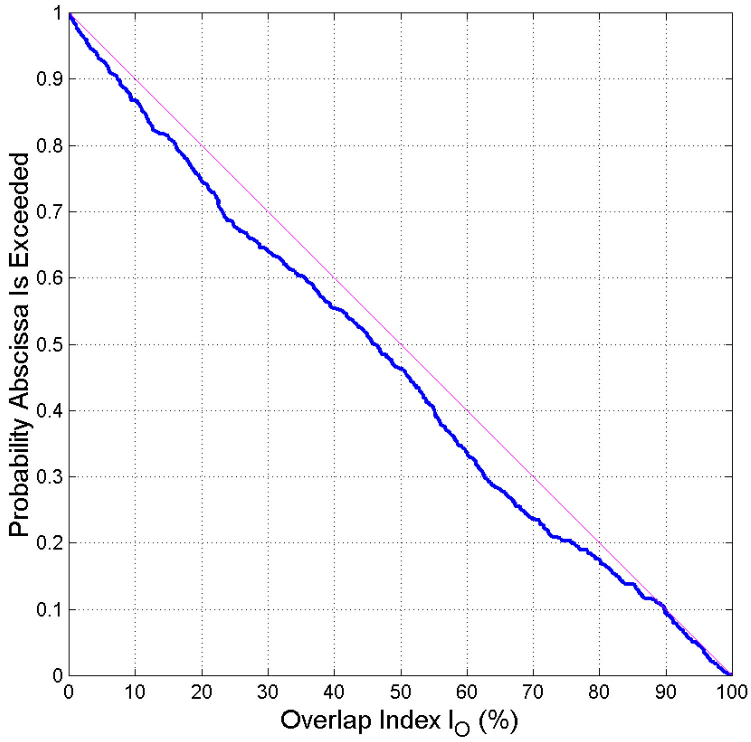


**Figure 5.** Probability distribution function of exceeding the overlap index $I_O(\%)$ in abscissa.

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.

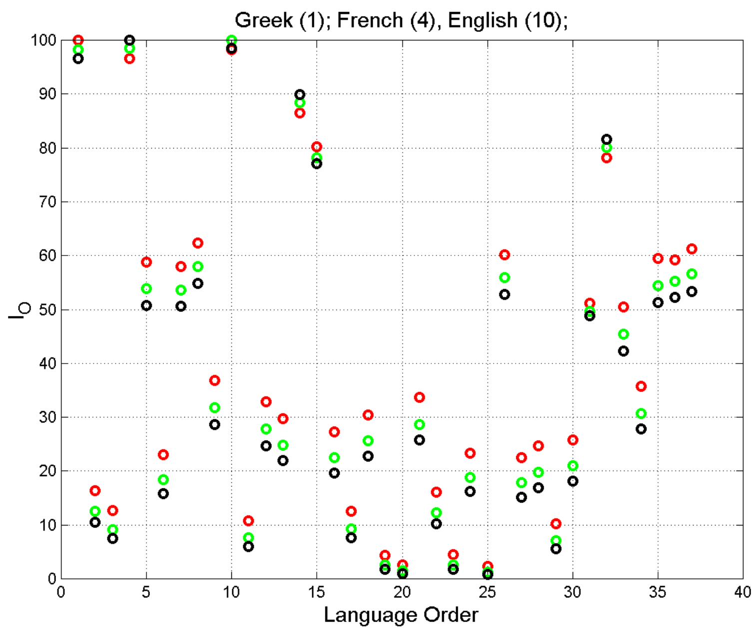


**Figure 6.** Scatterplot of the overlap index $I_O(\%)$ versus language by assuming as reference language Greek (red circles), French (black circles) and English (Green circles).

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 $r_O$.

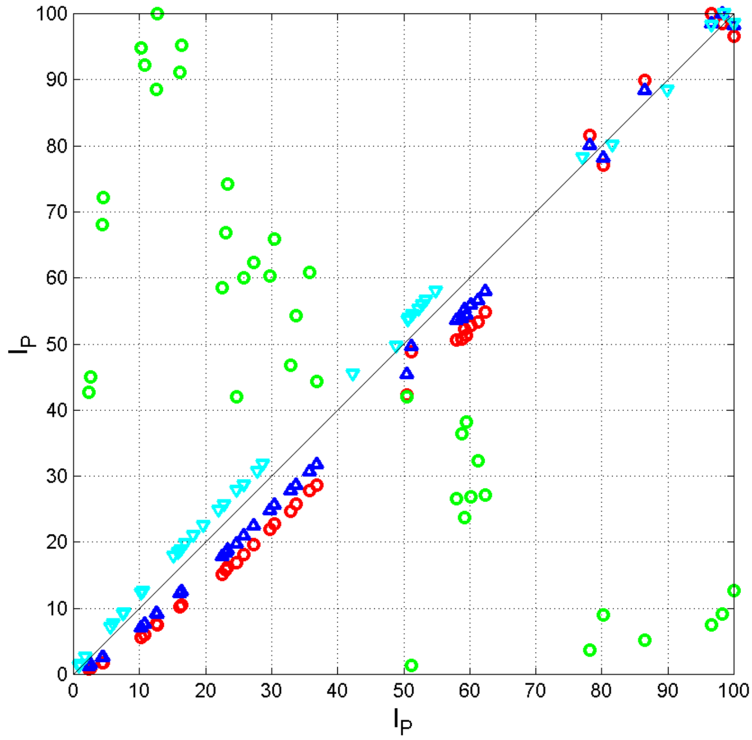


**Figure 7.** Scatterplot of $I_P$ and regression line of $I_P$ in two languages, for several cases. French ($y$) versus Greek ($x$) (red circles), English versus Greek (blue upward triangles), English versus French (cyan downward triangles), Spanish versus Greek (green circles).

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

$$R = r_O^2 \qquad (6)$$

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) $R > 0.95$, 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.

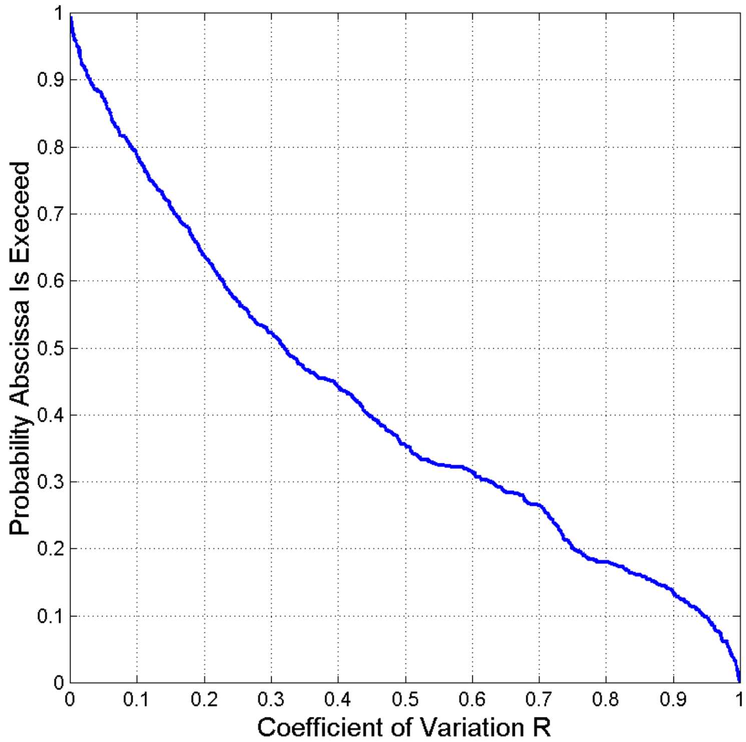


**Figure 8.** Probability distribution function of exceeding the coefficient of variation $R$ in abscissa.

**Table 2.** Reference language for which the coefficient of variation $R > 0.95$ in the indicated languages. Data taken from Table B1 (Appendix B) only 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, Slovack |
| 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 |

## 5. Universal Reader of the New Testament

As mentioned in Section 2, the global 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 distribution density of a population of "universal" readers who can read, as far as the STM capacity is concerned, any NT translation.

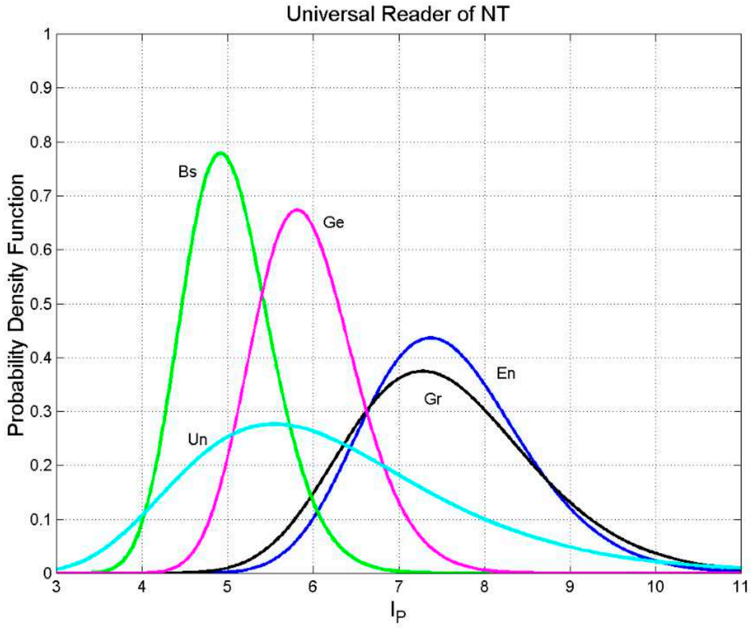


**Figure 9.** Probability density function $f(I_P)$ for the Universal Reader (Un, cyan line), German (Ge, magenta line), English (En, blue line) and Greek (Gr, black line).

Figure 10 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, of readers of its translations to Latin and modern languages. A similar study could be done with other alphabetical texts belonging to any literature.

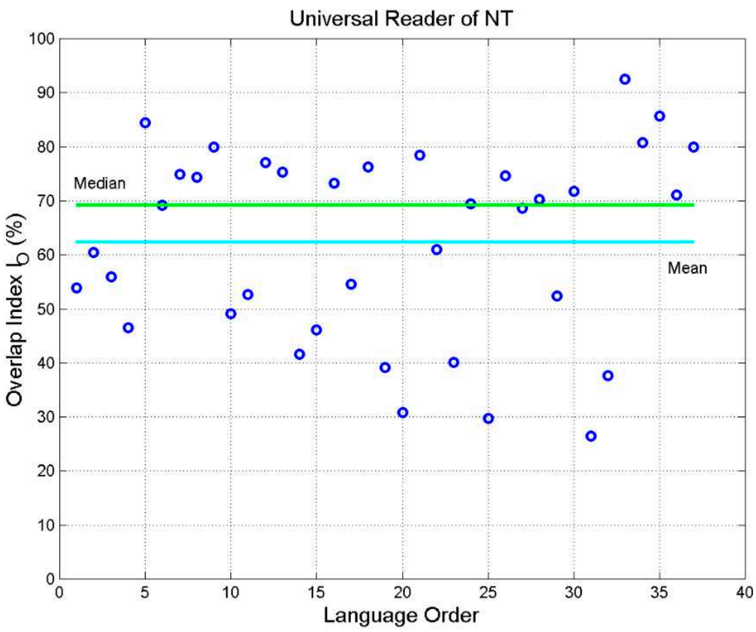


**Figure 10.** Overlap index $I_O$ (%) of the probability density function $f(I_P)$ of the languages in abscissa with the probability density function of the universal reader. The mean is 62.55%, the median is 69.20%.

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For modelling the STM capacity, we have considered the number of words per interpunctions, namely the "word 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 alphabetival text, we can perform experiments 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 Appendices A and B can give details on the other languages.

We have also defined a population of universal readers, namely readers who can read (and understand) any alphabetical 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.

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**Conflicts of Interest:** The author declares no conflict of interest.

## 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, the 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 |

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| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 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 |
| 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 |

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| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 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 |
| 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 |

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| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 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 |
| 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 |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 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 |
| 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 $r_0$**

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**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 |
| 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 |
| 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 |
| 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 |

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|---|---|---|---|---|---|---|---|
| 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 |
| 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 |

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|---|---|---|---|---|---|---|---|
| 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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