An Application of Software Engineering that Argues Against Erasmus Regarding the Pronunciation of Ancient Greek Digraphs

Evangelos C. Papakitsos

Abstract— According to the renowned Dutch philologist Desiderius Erasmus, the modern Greek script originates from ancient Greek and is also historical, because the words are written as they were once pronounced and not as they are pronounced today. A main assumption of his regards the pronunciation of digraphs as two separate phonemes, instead of a single one, according to the traditional rule. Although this assumption has been strongly opposed by many scholars, it has been also widely adopted by the scientific community, contrary to any piece of evidence that exists on the Greek literary tradition. The present study summarizes the older arguments against the Erasmian pronunciation of certain digraphs and presents some new ones. Moreover, it demonstrates a software application of computational stichometry that exhibits relevant measurements in Ancient Greek epic poetry, verifying the traditional rules of pronunciation.

Index Terms— Ancient Greek, Greek language, Erasmian pronunciation, computational stichometry, epic poetry.

1 Introduction

Ever since the Dutch philologist Desiderius Erasmus (1457-1536 CE) wrote his book, titled "Dialogus de recta latini graeciguae serminis pronunciatione" (1528), on the supposingly correct pronunciation of the Ancient Greek scripts, a scientific debate over this issue began [1]. Various scholars, such as the Spanish humanist Antonio of Lebrija (1444-1522) in 1503, have contributed, and still do, arguments for the Erasmus' view that the Ancient Greek language was pronounced, among others, with distinct vowels in the case of digraphs [2]. Other scholars strongly disagreed with this position, later on, like G. Curtius (1820-1895 CE) and Grassman, that find Erasmus' views untrue and proclaim that the phonemes do not change, the ancient and the new phonemes are the same, and simply in Ancient Greek, Persian and other languages there are various phonetic alterations, for reasons of formation [3]. Therefore, according to the latter view, the pronunciation of digraphs was then as it is today, since they existed to achieve orthographic and semantic differentiation [4].

The present study is focused on the particular case of four extremely common *digraphs*: AI (αι), EI (ει), OI (οι) and OY (ου). The Erasmian pronunciation suggests that the phonemes of these digraphs are pronounced separately, i.e., /ai/, /ei/, /oi/ and /ou/ respectively. The traditional pronunciation though attributes to these digraphs four single long phonemes /e/, /i/, /i/ and /u/ respectively. In order to determine the correctness of each position, a computational method has been tested herein, based on computational stichometry [5].

• *Evangelos C. Papakitsos is currently a member of the academic staff at the Department of Industrial Design & Production Engineering in the University of West Attica, Greece, PH-306945928206. E-mail: papakitsev@uniwa.gr*

2 The Debate

According to Erasmus, the modern Greek script, along with nowadays scripts in Latin characters like English, French, German, etc., originate from ancient Greek and are also historical, because the words are written as they were once pronounced and not as they are pronounced today. Erasmus, having started from the thought that the Ancient Greeks could not have possibly started to write with many signs (letters) for the same sound (e.g.: Y/H/I = /i/), came to the following plausible conclusion (but only as far as the Greek script is concerned) that [6]:

- The modern Greek script and the scripts with Latin characters are historical, because they write the words as they are depicted from the ancient Greek and Latin language.
- The modern Greek script also maintains the letters Ω, H, Y that are retained in the writing of the words, although they ceased to represent phonemes of the Greek language, coinciding with the pronunciation of O and I.
- The Ancient Greek language was different from the modern one, because it contained the sounds that were written with these letters (Ω, H, Y), where, e.g., the letter H was pronounced as long /e/ or that digraph AI was pronounced as two sounds (/ai/) instead of one (/e/).

The above view of Erasmus had, even since then, provoked a reaction from many scholars, Greeks and foreigners, such as K. Ragavis or the Bavarian philologist J. Reuhlin (1445-1522 CE), because they insisted on pronouncing the letters not as suggested by Erasmus [7], saying that this was neither in the Byzantine tradition nor referred by the ancient writers. Nevertheless, the above view of the Greek writing system penetrated then (in the 16th century) into foreign universities and then into Greek, through the writings of linguists like Saussure and others [6].

2.1 The Right Assumptions of Erasmus

Writing in Latin characters is indeed historical. By observing the current writings in Latin characters (English, French, etc.), it can be seen that the words originating from the Greek and Latin scripts are written exactly as they are there, regardless of how they are pronounced in the various languages that use the Latin alphabet. Words of other languages (e.g., Arabic, Hebrew, etc.) have also passed into these scripts through their Greek or Latin orthography (e.g., Algebra, Emmanuel, etc.). Therefore, writing a word in the above way remains unchanged in time, even if its pronunciation changes or if the word is said with two or more accents; the spelling of a word in the above way is pronounced differently in one language and differently in another, although the same alphabet (Latin) has been used; in order to indicate the correct pronunciation of words in Latin characters in dictionaries, the phonetic symbols are used in parallel. So, Erasmus speaks correctly about scripts in Latin characters (e.g., English, French, etc.) being indeed historical, because there is a mismatch between writing and pronunciation. For many words, it is impossible to say exactly what their pronunciation is, unless you know the whole word [6].

2.2 The Wrong Assumptions of Erasmus

On the contrary, Greek writing is not historical, but phonetic and at the same time etymological. By observing the Greek script, it can be seen that the words, since ever, are recorded neither accidentally nor historically, as the current scripts in Latin characters, but just as they are pronounced phonologically and, at the same time, depending on their etymology. Namely, the words are written depending on the part-of-speech, the type of the meaning of the word and the root or the original word. For example, the letters O and Ω (/o/) have been devised for this purpose, so that the reader can have help in finding the correct meaning of the words and in distinguishing between words of the same pronunciation but different meaning, as with the words ΚΑΛΟ ("good") and ΚΑΛΩ (to call). Therefore, Erasmus (and Saussure) do not speak correctly about the modern Greek writing, as being historical, judging from the scripts of their own languages [6].

Some results of the above erroneous view that Erasmus had of the Greek language and script were [6]:

- To have difficult textbooks of Greek written for writing (grammar) and language, which cause daily dyslexia or difficulty and even aversion to writing for students of Greek.
- The Greek writing system to be considered as a most difficult and paradoxical writing system and thus to acquire too many opponents, even Greeks, who constantly demand its abolition and replacement with the Latin or with another that has as many letters as the phonemes. Something wrong of course, because to write the words only phonographically in many cases does not make sense, due to the phonetically identical words (e.g., compare the English "too" and "two"). Therefore, the only way out in writing is the Greek etymological system of writing.

2.3 Arguments Against the Erasmian Pronunciation

The main arguments against the Erasmian pronunciation, both older and new ones, will be now summarized below.

1. The Greek language is the longest documented alive one of this planet. The first texts are dated 35 centuries ago (approx. 1450 BCE), in Linear B script [8], and continuous, with a relatively small gap (9th – 11th centuries BCE). According to Browning [9], "Since then (7th century BCE) the Greek language acquires a continuous tradition that reaches our time. Of course, there were changes but no rift was created afterwards, as was the case between Latin and Romance languages. Ancient Greek is not a foreign language for today's Greeks, as is the case with Anglo-Saxon for modern English (…). The continuity of its lexical stock (of Greek) is impressive (…). And despite the fact that there have been many rearrangements of morphological patterns, there has been also great coherence; so Greek is, even today, quite clearly an archaic, Indo-European type of language, such as Latin (…)." Within this context, the assumptions of Erasmus and of his advocates about the pronunciation of the Ancient Greek have never been mentioned nor implied anywhere in the Greek literary tradition (on the contrary, see below).
2. Plato in "Cratylus" (426-442) clearly states, among others, that the letter H is pronounced like I or EI, being just a variation of them (/i/) for reasons of better expression [6].
3. If the Greek writing was historical, then the words of modern Greek would have been always written with the same letters, something that does not happen, e.g., the ancient ΦΑΟΣ and the modern ΦΩΣ ("light") [6].
4. Countless words of Ancient Greek ending in digraphs, e.g., κυριαρχ-οι ("sovereign"), would have the tonal sign (i.e., -ί-) one syllable below (i.e., κυρι-ά-ρχοι), since it is not possible to have a word stressed above the ultra-penultimate syllable ("the rule of trisyllabic stressing") [6]. In fact, this piece of argument alone should have been enough for abandoning the Erasmian assumption about digraphs.
5. Spelling mistakes would not be found in ancient texts (while a lot can be seen), since mistakes are made in spelling only when there are letters of similar sound and it is not known how to be used in a word [6].
6. If the letters O/Ω, H/I and others of the same sound are missing from writing, the reader cannot distinguish between countless words of masculine or feminine gender, singular or plural, verb or noun, etc. [6]. For example, compare ΦΙΛΙ ("kiss", neuter singular) and ΦΥΛΗ ("race/tribe", feminine singular), both pronounced /fi`li/ (stressed on the ultimate syllable).
7. The very first indication that the digraph AI (αι) was pronounced as a single vocalic phoneme (/ə/) can be found in Linear B script, where in the word Λαυρά-ται the ultimate syllable (-ται) is written with a syllabogram (designated LB 66) that renders a single vocalic phoneme [10], [11].

8. From earlier computational applications of automated scansion in Homeric epic poetry [12], it has been observed that digraphs were normally pronounced as a single phoneme. In the first seven verses of Iliad, there are two words, Πηλ-ηϊ-άδεω (verse 1) and Ἀτρ-εΐ-δης (verse 7) that contain the standard digraphs -ηι- (ηϊ) and -ει- (εΐ) respectively. In order to have the desired metrical pattern achieved, their second vowel (-ι-) is marked with the diacritics of separation (-ϊ-, -΄ι-), namely, -ηϊ- is pronounced /ii/ and -εΐ- is pronounced /ei/ (both as two separate phonemes). If the assumption of Erasmus about digraphs was correct, then these diacritics would have not been marked, being unnecessary.

This last observation (2.3.8) has been further enquired in the herein research and in a massive scale [5], as presented in the next sections. The prosodic properties of Homeric epic poetry in hexameter metrical pattern have been very enlightening, regarding the true pronunciation of digraphs in Ancient Greek.

3 Epic Poetry

In the poetry of modern languages, rhythm is measured by the differentiation of pronunciation and the stress of syllables. That is, one unaccented syllable is short and one accented is long [13], [14]. This property (short/long) is called *quantity* and indicates the duration of the syllable's pronunciation [12], [15], [16], [17]. But in ancient Greek and Latin poetry, the quantity of syllables was based on the corresponding vowel length of the syllable and not on the stress. In the Greek alphabet there are seven vowels (α, ε, η, ι, ο, υ, ω), of which conventionally:

- two have been regarded as *short* (ε, ο);
- two have been regarded as *long* (η, ω);
- and the rest are called *dichronae* (α, ι, υ), since they can be either short or long, as the case may be.

The poem consists of verses (lines) and the verse is a sequence of syllables. Ancient poets had to align their verses following the rhythm of the music. That is, short syllables corresponded to short notes and long syllables to long notes. Comparison of ancient Greek with other verses of ancient Indo-European poetry (Sanskrit, Iranian, Slavic and Celtic) shows that this principle was common [18]. The study of the rhythm of the verses was called metrical analysis and their specific type meter. There are two main types of Ancient Greek verse [14]:

- the *lyrical* type that seems to have been sung and
- the *stichic* type that seems to have been recited.

Depending on the type, the poems were composed of different rhythms, with the exception of either the drama, where rhythms of both types may have coexisted, or the irregular verses [19]. The study of metrical theory began at least in the 5th century BCE, but it seems that the only important writer who dealt with it was one of Pericles' teachers, Damon [20]. The rest of our knowledge comes from writers of the Roman and Byzantine periods.

3.1 The Hexameter

The oldest known Greek stichic meter is the hexameter, which was established as the meter of epic, sophistic and non-dramatic poetry (although it is occasionally found in individual verses in dramas). Both Hesiod and Homer used this meter for their poems, while the use of the hexameter continued after the Classical era.

As its name implies, the verse in hexameter consists of six parts, called *feet*. Each foot can be either the trisyllabic *dactylic* (a sequence of long-short-short syllables) or the disyllabic *spondaic* one (a sequence of long-long syllables). The dominant foot is the dactylic one. The syllables are either short or long (quantity) depending on their vowel's or their digraph's length, of which they are composed, and their surrounding consonants, depending on the rules of prosody [12]. The overall syllabic pattern is presented in Table 1, where it can be seen that a verse in hexameter may have from 12 to 17 syllables, according to its composition of spondaic and dactylic feet. Verses of 12 or 13 syllables are extremely rare.

TABLE 1
Syllabic Patterns of the Hexameter

No. of feet per verse			No. of syllables per verse	
Spondaic	Dactylic	Total	Syllables per foot	Total
6	0	6	6×2	12
5	1	6	(5×2) + (1×3)	13
4	2	6	(4×2) + (2×3)	14
3	3	6	(3×2) + (3×3)	15
2	4	6	(2×2) + (4×3)	16
1	5	6	(1×2) + (5×3)	17

3.2 The Golden Ratio Φ

It has been estimated (with no such accurate methods) that the average long syllable is between 1.6 and 1.8 times the duration of a short one [18]. This relationship between long and short syllables is quantitatively close to the number Φ (= 1.618 ...). The number Φ is known in Mathematics, Science and Art as the golden intersection, the golden ratio, the golden rule, the golden mediocrity, the Divine analogy and, according to Euclid, the extreme and mean ratio. According to its definition, two numbers {α} and {β} have a golden ratio, when the ratio of their sum (α + β) to the larger number (α) is equal to the ratio of the larger number (α) to the smaller one (β) [21]: (α + β) / α = α / β.

The astronomer Johannes Kepler (1571–1630) proved that the number Φ is the limit of the sequence of the ratios of successive terms (in + 1 / in) of the Fibonacci series [22]. The golden ratio has been used by mathematicians to study geometric shapes, by architects and artists in their works, by economists to study market behavior, and by physicists to observe the properties of natural objects. In the present work, it is used for the study of metrical analysis in epic poetry [5], due to the previously observed ratio in the pronunciation of long/short vowels. The developed herein software has been an experimental application of this idea to computational stichometry.

4 The Methodology

The creation of this software application has been inspired by the observed ratio of pronunciation between long/short vowels,

which approximates the value of the number Φ (= 1.618). Its purpose is to measure and record the duration of the recitation of the verses in epic poetry [5], regardless of the classical metrical analysis, based on the feet and the rules of prosody. This recording includes both vowels and consonants, which consonants are examined only indirectly in the classical study of metrical analysis, in order to determine the quantity of syllables. Thus, in the present work, the consonants participate equally with the vowels in calculating the duration of the recitation of verses, written in hexameter.

4.1 The Duration Values

The duration of pronunciation is expressed in time units (1 TU) and with the number Φ. Consequently, depending on the duration of pronunciation for each letter/phoneme, as shown by previous relevant works [18], [23], the following categories of letters have been determined:

- The long vowels (η, ω) have a duration Φ (TU), relatively to the short ones' (see next) that is set as the conventional/relative unit of measurement herein; the actual times are of the order of millisecond [24].
- The duration (S) of short vowels (ε, ο) is equal to 1: S = 1 (TU).
- The duration of dichronae vowels (α, ι, υ) is considered short (= 1), unless they are aspirated, circumflexed or signed, in which case it is calculated as long (= Φ); the prerequisite for the second type of calculation is that the programming language can cope with the Greek polytonal system of writing.
- The duration of the crucial digraphs (αι, ει, οι, and ου) is considered long (= Φ), when measured traditionally.
- The *closed* consonants (β, γ, δ, κ, π, τ), where the first three are regarded as closed in Ancient Greek [25]; their duration (C) has been estimated in comparison to the duration of short vowels (S): S/C = Φ => C = S/Φ = 1/Φ = Φ – 1 (due to the properties of number Φ).
- The *enduring* consonants (ζ, θ, λ, μ, ν, ρ, σ, φ, χ) have a duration comparable to short vowels (= 1).
- The *double* consonants (ξ, ψ), which phonetically are the addition of a closed consonant to an enduring one (ξ = κ + σ and ψ = π + σ), have a duration comparable to long vowels (= C + 1 = Φ – 1 + 1 = Φ).

Therefore, to summarize the duration values: there are closed consonants (= Φ – 1 TU); enduring consonants, short and occasionally dichronae vowels (= 1 TU); double consonants, long and occasionally dichronae vowels (= Φ TU).

4.2 The Measuring Process

The *Organizational Method for Analyzing Systems* (OMAS-III) [26] has been used for the development of this software tool, identifying purposes, inputs, outputs, rules, monitoring and the structure of the application. Accordingly, a text file, written in the Ancient Greek language with verses in epic poetry, is converted at the input of the software system so as to record the duration of each verse at the output of the system. Initially, the duration of each verse is expressed in a number of units (1) and Φ numbers. Then, the final duration of each verse is marked algebraically, with an approximate value of Φ (= 1.62). In addition, the deviation (%) from the average value (±) is recorded, which average value is calculated from all the verses of the file. Various versions have been tested, regarding the assigned duration to the letters and to the whole syllables. The results are presented and discussed in the following section.

5 Results & Discussion

Both the subjects of singing in Ancient Greek music [27] and of emphasis in general [28] are considered quite complex. Nevertheless, according to the perception of the Ancient Greek scholars, a long syllable had twice the quantity of a short one, the latter considered here as the time unit (1 TU). Similar was their view about the duration of short and long phonemes [29]. The total duration of the recitation of the verse results from the sum of the quantities of its syllables. Therefore, in the classical view, there is no difference in the duration of a verse, regardless of its number of syllables (Table 2). Consequently, the duration of every verse had the standard value of 24 TU, with 4 TU per foot (4×6 = 24), which was the reason for keeping the rhythm of recitation by striking the foot on the floor, six times per verse (hence the terminology "hexameter" and "foot").

TABLE 2
TYPICAL SYLLABIC STRUCTURE OF THE VERSES IN HEXAMETER AND DURATION OF RECITATION FOR EACH VERSE (CLASSICAL VIEW)

Number of syllables per verse	No. of long syllables (× 2 TU)	No. of short syllables (× 1 TU)	Total duration of verse (in TU)
12	12		12 × 2 = 24
13	11	2	(11 × 2) + 2 = 24
14	10	4	(10 × 2) + 4 = 24
15	9	6	(9 × 2) + 6 = 24
16	8	8	(8 × 2) + 8 = 24
17	7	10	(7 × 2) + 10 = 24

By adopting the Φ-measure to the entire syllable (instead of each letter), a small deviation is observed. Namely, if a long syllable is regarded as having a duration of 1.62 TU (= Φ) instead of 2 TU, then the theoretical total duration of verses varies from 19.44 TU (for the extremely rare 12-syllables verse) to 21.34 TU (for a 17-syllables verse). The average value of the duration of recitation of the verses depends on the composition of the poem with verses of different sizes (i.e., number of syllables). The composition of rhapsody α΄of Odyssey, measured with values calculated according to the Φ-measure, presents an average duration of 20.89 TU. In this case [5]:

- the deviation (%) of 17-syllables verses (21.34 TU) is +2.15%
- and the deviation (%) of 14-syllables verses (20.20 TU) is -3.30%.

These are more or less the acceptable values of deviation from the average duration of recitation. It is noted that out of

444 verses of rhapsody α' (Odyssey) there is only a single verse having 13 syllables.

After testing in rhapsody α' (Odyssey) the Erasmian assumption about the pronunciation of digraphs {αι, ει, οι, ου} as two separate phonemes, instead of a single long one (according to the traditional rule), deviations between -18% to +20% have been observed [5], which are too large to be acceptable. In addition, verses of 18 and 19 syllables appeared, which exceed the upper limit of 17 syllables for the verses in hexameter (Table 1). This is a clear result of counting more syllables than the actual ones, due to the separate pronunciation of the letters of these digraphs, as different phonemes.

6 Conclusion

In conclusion, it has been demonstrated herein that the Erasmian pronunciation of Ancient Greek, regarding digraphs, has been widely adopted by the scientific community, solely based on the assumptions of Erasmus and contrary to any piece of evidence that exists on the Greek literary tradition. All the ancient sources, both directly, as in the case of Plato (see 2.3.2), and indirectly, as in the case of Linear B (see 2.3.7) and epic poetry, demonstrate that the assumptions of Erasmus about digraphs violate very strict rules of intonation (see 2.3.4), prosody and metrical structuring of the Greek language. Therefore, it is about time to be abandoned, in favour of the traditional correct pronunciation that considers the herein examined digraphs (αι, ει, οι, ου) to render single phonemes, diachronically.

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