

Designing the automation of data retrieval for processing the corpora of the Cretan Protolinear scripts

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ABSTRACT

The present study is focused on the extension of software facilities on a computerized platform that, once designed in details and implemented, will facilitate the study of the corpora of the Cretan Protolinear scripts and potentially will assist the decipherment of these that are still render unknown languages. The Cretan Protolinear scripts consist of Cretan Hieroglyphics, Linear-A and Linear-B, with their pictographic relatives the scripts of Cyprus. Linear-B renders the oldest-known version of Greek, Linear-A is undeciphered, while it has been demonstrated/suggested that the Cretan Hieroglyphics convey meaningful interpretations in Archaic Sumerian. This study exemplifies the proposed extension through an integrated platform for the exemplary processing of Linear-A corpus, where the technical solutions regard the increasing of automation for data retrieval.

KEYWORDS: Cretan Protolinear, Cretan Hieroglyphics, Linear-A, Linear-B, educational software, decipherment, ancient scripts, natural language processing.

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I. INTRODUCTION

The earliest manifestations of the Cretan Proto-Linear script are the Cretan Hieroglyphics and the Linear-A script; therefore, the latter is also known as simply Proto-Linear [1], being one of the world's great archaeological mysteries. Used by the Minoan civilization on ancient Crete (but also found elsewhere) from roughly 1800 to 1450 BCE, it remains entirely undeciphered. While we can read the sounds of words based on its successor, Linear-B, the actual language it represents is unknown. Linear-A is a complex writing system that combines different types of symbols. It was primarily written from left to right on clay tablets, pottery, and stone offering tables. These symbols comprise:

- Syllabic signs, called syllabograms, which consist the bulk of the script, representing open syllables that mainly render a preceding consonant and a following vowel (e.g., pa, ti, do); there are roughly 90 to 100 of these characters.
- Ideograms/Logograms that are pictorial signs representing specific objects or commodities, such as wheat, olives, wine, or livestock.
- Fractional and numerical symbols that are utilized, being a sophisticated system of mathematical notation for numbers and fractions, represented by various semicircular and dashed marks.

Conventionally, Linear-A is considered the direct ancestor of Linear-B, the script used by the Mycenaean Greeks. Because they share many identical signs, scholars can apply the phonetic values of Linear-B to Linear-A. However, this creates a “phonetic wall”. Even when we pronounce the words, they do not resemble Greek or any other known language family (such as Indo-European or Semitic). This unknown tongue is simply referred to as the “Minoan language”.

While Linear-B was almost exclusively used for cold, hard bureaucracy (inventories and taxes), Linear-A appears to have had a broader cultural reach, regarding:

- *Administration*, due to the large archives of clay tablets found at sites like Hagia Triada of Crete that show it was used to track agricultural surplus.
- *Religious Rituals*, since Linear-A has been found on “libation tables” in mountain sanctuaries, suggesting it was used for dedications to deities.

- *Daily Life*, because of inscriptions that have been found on jewelry, pottery, and even the walls of houses (graffiti), indicating a higher level of literacy among the Minoan population, compared to later periods.
- Linear-A has been proved hard to crack. Decipherment typically requires a bilingual text (like the Rosetta Stone) or a large enough corpus of data to find patterns. Yet, Linear-A suffers from:
- Short texts, as most inscriptions are brief lists rather than narrative sentences.
 - Limited data, because there are only about 7,500 characters in the entire known Linear-A corpus (compared to over 30,000 for Linear-B).
 - No living relatives, since without a known daughter language, the meanings of the words remain locked in the past.

Working with Linear-A today involves a mix of academic databases, specialized analysis tools, and modern AI research projects (for a critical review start with [2]). Because the script is undeciphered, the software tools isn't for translation, but rather for studying the signs and for statistical analysis. The primary software resources and tools available for Linear-A are:

- Databases and digital explorers that are the most useful tools for viewing the actual inscriptions and searching for specific sign combinations; yet, they are not suitable for directly supporting automated processing and other Artificial Intelligence (AI) tools.
- Processing and AI tools, where researchers are increasingly using machine learning to look for patterns that the human eye might miss, although their corresponding databases are internal; therefore, they cannot be used like the above databases and digital explorers.

The most recently released software tools are the Deep Learning Models (MDAP) of "The Melbourne Data Analytics Platform" (2024–2026), which is actively using deep neural networks to investigate the "cognancy" (relatedness) of Linear-A to other ancient languages [3]. These models are trained on known languages like Ugaritic and then applied to the Linear-A corpus to find linguistic matches. The other software tool is a tentative integrated platform that contains a database (i.e., a machine-readable dictionary / MRD), directly accessible both by the users and a computer programming language, and a search-engine for relating Linear-A's words to other words of contemporary languages, initiated in 2019 [4]. The search-engine is accessible via an interactive interface that can be also utilized for educational purposes [5], based on a similar platform for Linear-B script [6]. The present work will describe the recent extensions of the latter software tool that will eventually permit an increased automation of data retrieval.

II. METHODOLOGY

It has been argued that a potentially successful decipherment of Linear-A script has to abide with five prerequisites [7] that include the correct assignment of phonetic values to Linear-A [8] signs and the usage of efficient computational algorithms for this purpose [9]. The integrated platform is based on two linguistic theories, one per each prerequisite above, as presented next.

The Phonetic Values

The assignment of phonetic values is based on the linguistic theory of the Cretan Protoliner Script (CPS), which is the most detailed, comprehensive, complete and well-documented theory on the descent of the Aegean scripts [7]. Besides the relevant Comparative Linguistics [10] and pictographic studies [11], the CPS theory is supported by a plethora of anthropological and archaeological evidence [12], gathered, classified and evaluated with the application of Systems Engineering [13]. Accordingly, the repertoire of 120 syllabograms can be arranged in groups by several criteria, which include the number of syllables per sign (i.e., monosyllabic or disyllabic ones [14]), their theme that can be of human nature [15], animals [16] or culturally important objects [17], the initial phonetic values [18] or the preceding ones [19], and their appearance in different Aegean scripts [20].

The formation of the CPS theory initiated with the discovery of the linguistic affinity of the Sumerian language, as being an r-Altaic one and not a language-isolate [21]. This discovery fully explains the observed assigned phonetic values to the syllabograms of the Aegean scripts that some of them are still conventionally regarded as unknown [22]. Then, it was also revealed, along with the pictographic resemblance, that Cretan Hieroglyphics were merely the ornamental and ritual version of CPS [23]. Meaningful interpretations were suggested for emblematic inscriptions of the Minoan art/religion [24], which span beyond the Minoan era to the Eteocretan ones of the Classic Times [25] that also support the proof of their authenticity [26]. In addition, various cultural and linguistic suggestions and/or observation were made, regarding the potential ability of the CPS to allow literacy without schooling in Bronze Age Crete for the former [27], and the determination of etymologies of the Late Ancient Greek nomenclature for the latter [28]. In a very recent study, the CPS was utilized auxiliary to suggest the potential decipherment of the Indus Valley Script (IVS) [29]. After considering anthropological and cultural evidence on the ancient populations of the Indian Peninsula [30], this study comments on the IVS signs (and the rendered language) [31], both for the common and the less common ones

[32], as well as on the relevant phonology [33]. Finally, the CPS has been standardized to facilitate referencing/indexing and computational processing [34].

Computational Algorithms

The processing core of the integrated platform is the search-engine that technically executes a trivial serial search on the MRD, namely, a simple look-up of Linear-A's words. Yet, to discover possible cognates on the dictionaries of the target-languages, all words (both of Linear-A and the target-languages) in and for the search are substituted by their Syllabic Grouping equivalent [35]. This is simply a string per word that denotes the phonetic group of a consonant (i.e., labial, nasal, palatal, etc.) instead of the consonant itself. The same substitution happens for the single-syllable vowels; all other vowels, following a consonant, are stripped off. This technique is based on the linguistic theory of monogenesis and especially on the consequent reconstruction of the Proto-Sapiens language [36]; it is the only technique that can capture the phonetic alterations from one language to another, when a phoneme (sound) that doesn't exist in a language has to be substituted by another existing phoneme, to denote a certain word. As a proof-of-concept, Syllabic Grouping was successfully tested in the Anatolian languages' family, which are of well-known linguistic affinity [37].

III. APPLICATION

The visible to the user components of the integrated platform are the interface and the MRD. The former has been designed according to the systemic modelling of information, an approach similar to the designing of websites [38]. The latter initially consisted of the dictionary of Linear-A and the dictionaries of ten target-languages [39]. Later on, two more dictionaries of target-languages were available (not yet accessible by the search-engine) and a unique dictionary for the corpus of Linear-A [40]. As far as it is known to the author herein, the existing digital databases, mentioned earlier, may present the words of Linear-A in their context (e.g., a tablet or another inscribed artifact), but without the ability of processing them (i.e., find a potential match to another language). On the other hand and to the best of the herein author's knowledge, the existing processing tools, also mentioned earlier, allow the comparison of Linear-A's words to other words of several target-languages, but only in a word-by-word mode, regardless of their context.

Considering the previous deficiencies, to facilitate the users in comparing the various possible cognates, discovered by the search engine, in their context, which is the only way to discover whether a sequence of words make sense or not, the dictionary for the corpus of Linear-A was implemented [41], as a spreadsheet file (Fig. 3.1).

| | | | | | | | | | | | | |
|---|-------|----------|------------|------------|-----------|----------|---------------|--------|------------|-------|---------|----------|
| 1 | ARKH2 | SiDaTe | CuLaPo | [5] | ASiDaToNo | [12] | ZuLuSeDeQiDwo | [6] | ASuBuWa | [4] | "RuMi- | |
| 2 | HT1 | QeLjaU | CiLo | [197] | ZuSu | [70] | DiDiZaCe | [52] | CuBoNu | [109] | AlaNaLe | [105] |
| 3 | HT2 | ACaRu | (OLE+U 20) | (OLE+A 17) | (OLE+E 3) | CiLeTaNa | (OLE+A 47) | | | | | |
| 4 | HT6a | CaPa | DaTaLa | Te | Gi | [15] | PITaJa | [24] | (IA+RU ??) | MaBa | [10] | OLjaDiNe |
| 5 | HT6b | WaDuGiMi | [3+] | LaQoSe | [1] | MaLuNoNo | [3] | DuDaMa | [66] | DaCi | [3+] | SalMa |
| 6 | HT7a | QeQo | WoNoRuJa | [3] | DuJa | [4] | TaNaQo | [1] | DaLe | [1] | TeTu | [1] |
| 7 | HT7b | QiTuNe | [1] | DaRuHa | [2] | | | | | | | |

Figure 3.1: The digital partial corpus of Linear-A's complete tablets.

In each line of this file, every complete tablet has a serial number (Fig. 3.1: 1st column), the formal designation of it (Fig. 3.1: 2nd column), and then all the words, symbols of commodities (in parentheses), and numerals (in square brackets) aligned thereafter. The users may insert empty lines right below the line of a tablet, and place the various possible cognates, retrieved by the search-engine, word-by-word just below the corresponding word. Thereby, they may compare if the word-sequences make sense in the context. The entire corpus comprising five sheets that include:

- the complete tablets (Fig. 3.1),
- the fragmented tablets,
- the complete inscribed artifacts other than tablets that contain more than one words,
- the fragmented inscribed artifacts other than tablets that contain more than one words,
- and finally, the single-word inscriptions/artifacts.

Yet, this process has to be executed manually.

To allow the enhanced automation of data retrieval in future implementations of the integrated platform, an index-file has been designed, also implemented as a spreadsheet file, connecting the words of Linear-A to the artifacts that appear (Fig. 3.2).

| | | | | | | |
|-----|---------|---------|-----|----|----|--|
| AAS | AHəZa | | 116 | | | |
| ABC | APaCi | | | 7 | | |
| ABG | JaPaQa | | | | 18 | |
| ACB | JaCiBo | | 121 | | | |
| ACD | ACaDwo | | 24 | | | |
| ACD | ACaTa | | 113 | | | |
| ACD | JaCaDwo | | 13 | | | |
| ACG | ACaGo | | | 12 | | |
| ACL | ACaLa | | | 12 | | |
| ACL | ACaRu | 3,36,37 | | | | |

Figure 3.2: The index-file of the integrated platform for trisyllabic words.

Firstly, the words in the index-file are registered per number of syllables (i.e., monosyllabic, disyllabic, trisyllabic, four-syllabic, and five-plus-syllabic) in respective sheets. This arrangement has been decided for the entire MRD, followed since the beginnings of this series of works [42], in order to speed up the retrieval of data. The example of Figure 3.2 presents the indexes for 10 trisyllabic words. The 1st column contains their Syllabic Grouping designations, by which the search-engine executes any retrieval in the MRD. The 2nd column contains the word of Linear-A; the single-syllable vowels and the consonants of open syllables appear in capital letters, to have the number of syllables per word easily recognized. Then, in the next five columns (i.e., 3rd, 4th, 5th, 6th and 7th), the serial numbers of the corresponding words appear, according to the above type of artifacts/inscriptions (a)-(e), respectively. For example:

- the 2nd word (APaCi) appears in the 7th line of the sheet with the complete inscribed artifacts other than tablets that contain more than one words (c);
- the 3rd word (JaPaQa) appears in the 18th line of the sheet with the fragmented inscribed artifacts other than tablets that contain more than one words (d);
- the 7th word (JaCaDwo) appears in the 13th line of the sheet with the fragmented tablets (b);
- the 10th word (ACaRu) appears in the 3rd, 36th and 37th line of the sheet with the complete tablets (a).

None of the presented words are found in single-word inscriptions/artifacts (e), in the 7th column (Fig. 3.2). Through this index-file, the potential cognates of a Linear-A word can be automatically placed under this word, in every type of inscription that appears. Thereby, the users will have the whole picture of the corpus with every artifact to study, once the corresponding facility and algorithms will be designed in details and implemented.

IV. CONCLUSION

The described herein methodology and design cannot be realized only for Linear-A. It can be applicable to the corpora of inscriptions for any ancient language, once the corresponding software platform is created. If the rendered language of the inscriptions is known, as in the case of Linear-B, then this platform can be utilized as educational software that will help its users in studying the said language. In fact, this particular model of software is already modified to process the Coptic script (e.g., see [43]). More languages of this kind are Ancient Egyptian, Sumerian, Akkadian, Hittite, Luwian, etc. If the rendered language of the inscriptions is unknown, as in the case of Linear-A, then this platform can be utilized for software assisted decipherment. Such cases are Elamite, Indus Valley Script, and notably these scripts that need verification of their suggested decipherment, like Etruscan [44] or the related to the Aegean Scripts Cypro-Minoan [45]. This scientific and technological field still attracts international interest, especially for the Aegean scripts as demonstrated by recent studies (e.g., see [46]), and it is open to a lot of hard interdisciplinary work.

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