An Interactive Software Application for Exploring the Affinity of Linear-A Script to Other Contemporary Languages

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Abstract

Linear-A script is still regarded as the first indisputable writing system of Europe, along with Cretan Hieroglyphics. It appeared mainly in Minoan Crete between 1800 and 1450 BCE. This script has not yet been deciphered, except from the symbols of commodities and the numerical values, as well as anthroponyms, theonyms and toponyms that still remain of unknown etymology. The proposals for the rendered by the script languages include a large variety that comprises most of the contemporary languages of the major region and beyond. Therefore, the presented herein software application aims at assisting scholars to study the potential relations of Linear-A to its contemporary languages, through an interactive digital environment. A lexicon supports the whole process, while several quantitative relations have been recorded.

Keywords: Minoan Language, Minoan Crete, Linear-A, Natural Language Processing, Syllabic Grouping.

1. INTRODUCTION

Linear-A existed in the era of Minoan Crete from 1800 to 1450 BCE and consisted of a mainly commercial writing language, primarily used in palatial and religious writings of the Minoan Civilization. Linear B was its successor and is considered as conveying the earliest form of Greek language known. Sir Arthur Evans, in 1900, discovered it and found some texts, written mainly on clay tablets that have not yet been deciphered. The only thing that was deciphered are numerical values, but the words – besides anthroponyms, toponyms or theonyms – remain of unknown origin. Artifacts with Linear-A inscriptions were found mainly in Crete, but also in other Greek cities, as well as in Turkey and Israel. Linear A has been written on various media, such as stone offering tables and vessels, gold and silver hairpins, roundels, and ceramics (Christidis, 2010).

The term “Linear” derives from the stylus to cut the lines into a tablet of clay. Archaeologist Arthur Evans named the script "Linear" because its characters consisted simply of lines inscribed in clay. There are many different views regarding the origin of the language. It consists of numerals

and metrical signs, ligatures and composite signs, phonetic signs ("syllabograms"), and ideograms.

The proposals for the rendered by Linear-A languages include a large variety that comprises most of the contemporary languages of the major region and beyond. As a first deciphering attempt, ten (10) contemporary languages have been chosen, belonging to two (2) groups, namely, the group of seven (7) Anatolian languages of the Indo-European family, plus a group of three (3) more languages of the contemporary Balkans and Anatolia, not related to each other. A brief description of these languages, in the following section, precedes the presentation of previous related works.

2. CONTEMPORARY LANGUAGES

2.1 Anatolian Languages

Carian

The Carian language is mentioned mainly in Hittite records and later in Homer's writings, when he refers to the golden armor of the Carian captain Nastes. It belongs to the Luwic group of the Anatolian family of languages and part of the Indo-European family, as was proven in 1996 (Adiego, 2007; 2013). The known vocabulary is small and mainly originated from Egypt. The Carian alphabet consisted of 34 characters and the writing form was from left to right (Shafer, 1965).

Etruscan

Throughout the 1st Millennium BCE, the Etruscan civilization had an impressive history and managed to retain a thriving culture, being one of the first great cultures of the Italian peninsula. The people of Etruria built great cities, gathered vast amounts of wealth and developed a sophisticated cultural system that largely influenced the Romans (Haynes, 2005). The earliest form of the Etruscan civilization is known as the Villanovan culture, being developed around the late 10th century BCE, making it the earliest Iron Age culture in the Italian peninsula. Etruria was already a fertile land, but iron tools and new farming techniques resulted in a massive agricultural growth. Furthermore, mineral resources such as iron, gold, copper and tin were extracted on a large scale. At around 750 BCE, the Etruscan culture would form. At the same time, the Phoenicians and the Greeks began establishing colonies around the Mediterranean Sea and trading with the Etruscans, mainly because of the rich mineral resources of Etruria. Slowly, independent city-states were transformed in the Etruscans and had control over the surrounding area. Around the 7th century BCE, a loose alliance among the 12 greatest Etruscan cities was established (Potts & Smith, 2022). A recent study classifies the Etruscan language as one belonging to the Anatolian family of Indo-European languages (Woudhuizen, 2019).

Hittite

In 1920, the Swiss scholar Emil Ferrer claimed that indeed the world of Mycenaean Greece had substantial contact with the Hittite Empire. Around the beginning of the 16th century BCE, it is said that Minoan immigrants from Crete established a city on the southwestern coast of today Turkey. By 1400 BCE, the Hittite Empire laid claim to this territory, as one of its Western vassal states across the Aegean Sea, where the Greek speaking Mycenaean city-states had already migrated and most likely there was a conflict occurred between the Hittites and groups of Mycenaean Greeks (Bryce, 2005). The Hittite language belongs to the Anatolian family of Indo-European languages (Yakubovich, 2020).

Lycian

Lycians appear in Homer's Iliad, where they're led by the hero Sarpedon and his cousin Glaucus; they fought for the Trojans during the Trojan war and their kingdom, known as Lycia, was along the Xanthus river. Texts of Lycian language are found in 150 inscriptions on stone, some 200 on coins and other objects. It was spoken up about the 3rd Century BCE, when the Lycians adopted Greek as their language. Lycian language is thought to have been developed from Luwian, a

language spoken in Asia Minor before the arrival of the Hittites (c. 18th century BCE), and was related to Lydian (Melchert, 2011; Patri, 2023).

Lydian

It is an extinct Indo-European Anatolian language, spoken in the region of Lydia, in western Anatolia (now in Turkey). The language is attested in graffiti and in coin legends from the late 8th century/early 7th century to the 3rd century BCE, but well-preserved inscriptions of significant length are so far limited to the 5th and the 4th century BCE, during the period of Persian domination (Encyclopedia Britannica, 2021). Thus, Lydian texts are effectively contemporaneous with those in Lycian. Extant Lydian texts now number slightly over 100, all but a few having been found in or near Sardis, the Lydian capital, but fewer than 30 of the inscriptions consist of more than a few words or are reasonably complete. Most of the inscriptions are on stone and are sepulchral in content, but several are decrees of one sort or another, and some half-dozen texts seem to be in verse, with a stress-based meter and vowel assonance at the end of the line (Laflı & Kan Şahin, 2017).

Luwian

During the 2nd millennium BCE, the Luwians were the biggest population group of Southwestern Anatolia. Luwian written forms are found both in Hieroglyphics and in cuneiform scripts. This happened as Luwian was split into many dialects, which were written in two different writing systems (Melchert, 2003). One of these was the Cuneiform Luwian, which used the form of Old Babylonian cuneiform that had been adapted for the Hittite language. The other was Hieroglyphic Luwian, which was written in a unique native hieroglyphic script. The differences between the dialects are minor, but they affect vocabulary, style and grammar. The different orthographies of the two writing systems may also hide some differences. Most of our knowledge about them comes from Hittite texts, since the language was largely expanded in the Hittite Empire. When the Hittite empire collapsed, the Luwian language was preserved and promoted as royal language among Neo-Hittite States of the early Iron Age (Vertegaal, 2020).

Palaic

Palaic is mainly found in cuneiform tablets in Bronze Age and in the capital of Hittites, Hattusa, attested between 1600-1200 BCE. It is part of the Indo-European languages of the era and is now extinct. It was mainly spoken in Northern Anatolia and is one of the four subdivision of the Anatolian languages. Palaic shows the same gender distinction as seen in Hittite and has similar pronoun forms. It was used as a liturgical language by the Hittites in the cult of Hattic gods (Adiego et al., 2019).

2.2 Other Languages

Phrygian

The ancient kingdom of Phrygia was a land of numerous Greek myths and legends, but also great political power that prospered throughout the iron age. The Phrygians were not unified into a single state, but scattered around various valleys and mountains, whose cities were likely under the sway of their more established neighbors, such as the still powerful Hittites to the East. Their language was spoken in the Anatolia region between the 8th and the 5th century BCE (Encyclopedia Britannica, 2023).

Thracian

This language is poorly attested and was spoken in ancient times in Southeast Europe by the Thracians (Krimpas, 2022). It is listed as an Indo-European language and was used until the 6th century CE, in different sources, such as proper names and glosses in Greek writings and a small number of inscriptions, some of which appear in coins (Soesbergen, 1979).

Hattic

The Hattic language was spoken in Asia Minor in the 2nd millennium BCE (Schrijver, 2019) and the Hattians were formed when, years ago, the Akkadian army of king Naram-Sin marched

towards the Anatolian plateau. King Pamba of the Hatti, king Zipani of Kanesh, king Tisbinki of Kussara, king Nur-Dagan of Purushanda and thirteen more kings from the Hatti lands had united against Akkadian rule. By 2500 BCE, the trading routes between the Hatti lands and Mesopotamia had been established and the Hattian civilization was empowered. From the 360 remaining Hattian fragments, only 300 words are available to us and not with a well-established meaning (Palaeolexicon, 2024).

3. PREVIOUS WORKS

To date, various possible relations between known languages of the Minoan era with Linear-A are referred to and documented in the literature. For example, Strabo mentions that around his time (i.e., 1st century BCE), the Lydian language was no longer spoken in Lydia proper but was still being spoken among the multicultural population of Kibyra (now Gölhisar) in southwestern Anatolia, by the descendants of the Lydian colonists, who had founded the city (Cahill, 2010). Herodotus claimed that the Etruscans were once the same people as the Lydians of Asia Minor. Dionysius of Halicarnassus though believed that the Etruscans were native to central Italy (Wade, 2007).

In 1920, Emil Ferrer claimed that indeed the world of Mycenaean Greece did in fact had substantial contact with the Hittite Empire and he had discovered proof that Hittite and Greeks knew each other and had mutual respect one another, as great powers. He drew this conclusion from references in Hittite texts to a land called “ajiyahwah“, which is the word for Ahhiyawa, the Greeks Acheans, a name that was used by Homer, the Greek poet, as well as a general name for the Greeks of the age of Heroes, whose scholars today identify as Mycenean Greeks (Poccetti & Logozzo, 2017). Everyone agreed with Ferrer. For example, the German linguist Ferdinand Summer dismissed the name similarity as nothing more than coincidence. As more Hittite sites are excavated and newly discovered texts translated, however, there seems to be more evidence to support Ferrer's hypothesis. One such piece of evidence is the so-called tawa gala letter, written in the 13th century BCE by a Hittite king, addressed to another unnamed king, about the relationship between Hittite and Ahhiyawa (Hardy, 1941).

Homer wrote in the 8th century BCE, some 500 years after the Trojan war, that around 1200 BCE the land known as Lycia went by another name, Luwia, whose people spoke Luwian, a language that was predominant throughout much of western Anatolia; at the time most scholars believed that these people were the late bronze age ancestors. Furthermore, studies by linguists Piero Meriggi (in 1936) and Holger Pedersen (in 1945) proved that Lycian is an Indo-European language closely related to Hittite and Luwian. In another series of studies (from 1958 to 1967), Emmanuel Laroche showed that Lycian shares several specific innovations with Luwian (The Ohio State University, 2024).

4. METHODOLOGY & IMPLEMENTATION

The development of the presented herein software tool followed the methodology of a family of related interactive Natural Language Processing tools, unique for allowing both the translation and learning of ancient scripts/languages, since they offer an integrated software environment, comprising a user-friendly interface, a machine-readable dictionary (lexicon) and a search-engine. Consequently, the general methodology for conducting the present project had been the standard deductive reasoning of the top-down design, as applied for the creation of the interface and the search-engine. A similar deductive approach was applied for the creation of the machine-readable dictionary, by using the entity-relationship model of database design (Bagui & Earp, 2022), implemented as described in subsection 4.1 “The Database”. Finally, because of the multilingual context of the herein project, the data analysis followed a statistical approach, by comparing the similarities of the target-languages (see section 2. CONTEMPORARY LANGUAGES) to the vocabulary of Linear-A.

Considering the above, the first such software tool has been developed for the study of Linear B script, the successor of Linear-A that shares most writing features with its predecessor, having

most syllabograms in common and rendering the most ancient known form of Greek, the so-called Mycenean Greek (Papakitsos et al., 2018). The second such software tool is being currently developed for studying the Egyptian Coptic language (Kontogianni et al., 2023). Yet, both these tools have to deal with a single target-language and known scripts, i.e., Mycenean Greek and Egyptian Coptic, while here there are 10 target-languages and an undeciphered script (i.e., Linear-A). This difference requires a modified approach, as described in the next paragraph.

Here, the method of Syllabic Grouping was chosen, which is a computational method of Natural Language Processing for discovering cognates in multilingual corpora and text collections. The lexical cognates are words of the same origin in different languages and seeking cognates through internet can be very useful for data mining in multilingual environments, especially when the purpose of retrieving information is sentiment analysis, namely the assessment of products and services by their users/customers. In that way, valuable information is preserved. Without considering multilingualism, valuable information can be missed. Since the individual opinions collected can be vast, depending on the subject, Big Data technology, which is a component of Industry 4.0, is crucial for sentiment analysis in combination with corpora linguistics. The Syllabic Grouping through graphemic matching is described through simple examples that demonstrate its future potentials (Papakitsos, 2021).

To make the interface user-friendly, we use the Visual Studio tool (C#). The interface helps researchers/students of Linear-A to discover and analyze in depth the findings of the inscriptions (Fig. 1). The database is designed and implemented as a spreadsheet, consisting of the vocabulary of Linear-A and of the nearby languages of that era (Mavridaki et al., 2020). The search algorithm firstly reads the inserted world in Linear-A and then it finds the equivalent form of Syllabic Grouping. Then, it uses that form to discover all the words of the contemporary languages in the database that have the same equivalent form. The results are returned in a box of the interface and saved in a text file, for further study.

4.1 The Database

Initially, a spreadsheet was created with all the known words in the respective languages of the era. Then we divided the words using the method of grouping syllables by their consonant, followed by grouping by vowels that may fit or belong to the same phonetic family.

Anatolian and other known languages during the Minoan era are supposed to have some common elements and relations between one another and potentially with Linear-A, which existed in that time too and has not been deciphered. Therefore, we first grouped the already known vocabulary in a separate spreadsheet for each language, followed by another spreadsheet with the known words from Linear-A. We will be comparing the words in the latter, against the words in each of the languages of the Minoan era. Such comparisons allow:

a) identifying the language(s) that are closer to Linear-A, and
b) which words of that language are phonetically similar and may have the same meaning.

To do so, we used syllabic grouping as explained in the Methodology Section. This method of grouping in two consecutive levels may lead the researcher/student of Linear-A to discover whether a word can be matched as definition and form in the texts; for the totality of the findings with Linear-A, text can be translated using all languages.

5. RESULTS & DISCUSSION

We started the phonetic matching by taking the already known vocabulary for each target language and comparing it by means of syllabic grouping, to examine if there were any similarities to Linear-A, yet excluding any attempt on determining meanings. This process was restricted to the equivalence of consonants between the working languages. We found that the main languages that are closer to Linear-A are the Etruscan language, with 730 possible common

words, followed by the Hittite language with 685 words and the Lycian language with 579 words (Table 1). Most similarities between languages appear in two- and three-syllabic words (Table 2).

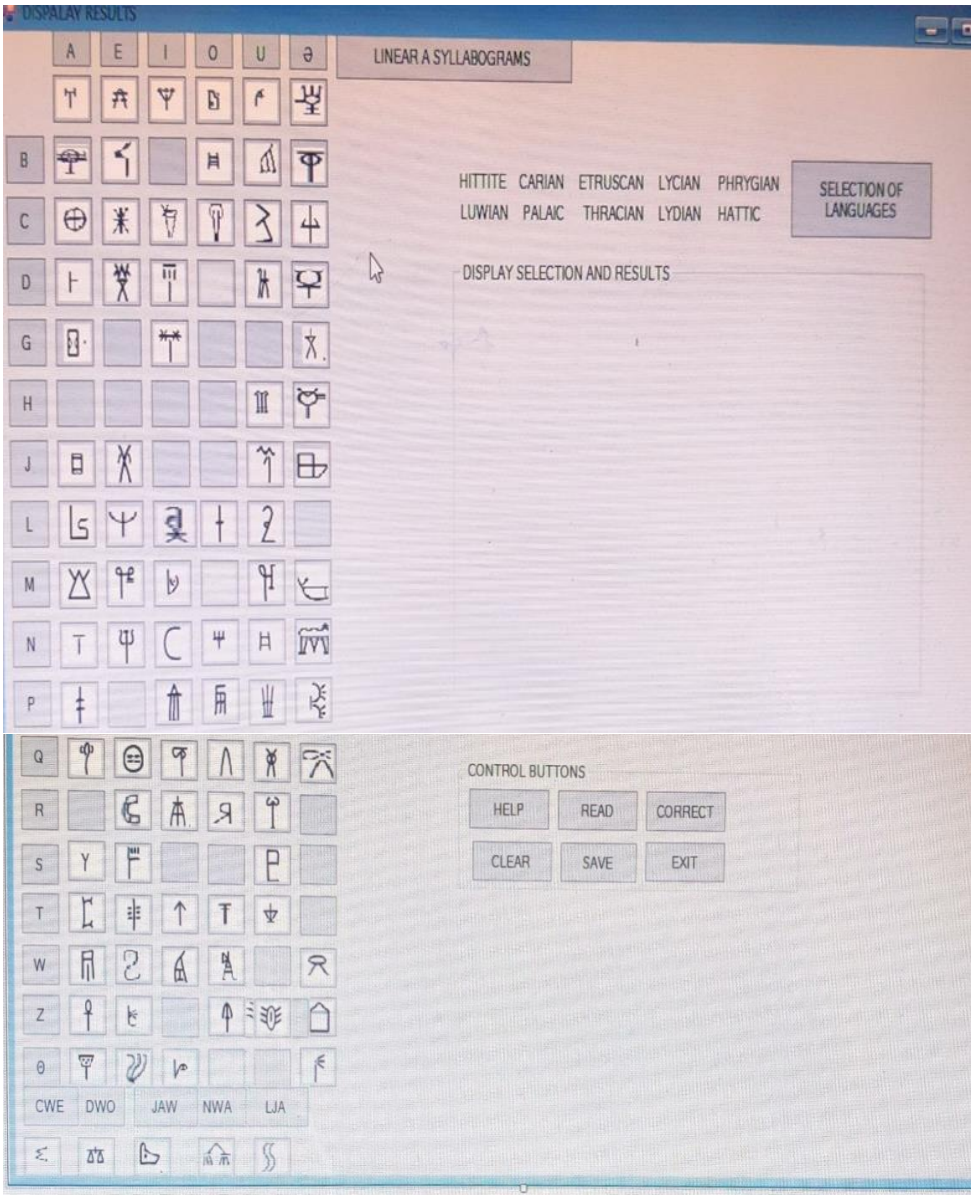

FIGURE 1: Screenshot of the tool's interface.

Language	*Etruscan*	*Hittite*	*Lycian*	*Phrygian*	*Thracian*
No. of Words	730	685	579	570	535
Language	*Hattic*	*Lydian*	*Carian*	*Luwian*	*Palaic*
No. of Words	411	397	382	254	196

TABLE 1: Total of similar words with Linear-A by language (consonants only).

However, when in addition to consonantal similarity we also include the vowels that follow the consonant of the syllable, the comparison yields some changes in terms of linguistic affinity. While the three first languages remain the same, it appears that the Lycian language is closer to Linear-A than the Hittite. In addition, the Etruscan language appears to have 183 words in

common and the Lycian language to have 148 words in common (Table 3). The big difference comes in the third place, where the Hittite language appears with 146 words in common.

Syllables per word	**1**	**2**	**3**	**4**	**5+**	Total
Linear-A	4	370	380	184	152	1090
Carian	10	295	68	9	0	382
Etruscan	3	567	155	5	0	730
Hattic	34	354	22	1	0	411
Hittite	12	613	58	2	0	685
Luwian	2	202	46	4	0	254
Lycian	14	475	90	0	0	579
Lydian	16	323	53	5	0	397
Palaic	5	164	27	0	0	196
Phrygian	10	458	97	5	0	570
Thracian	9	447	78	1	0	535
Total	115	3898	694	32	0	4739

TABLE 2: Words similarity per size of syllables (consonants only).

Language	*Etruscan*	*Lycian*	*Hittite*	*Phrygian*	*Hattic*
No. of Words	183	148	146	111	109
Language	*Carian*	*Thracian*	*Lydian*	*Luwian*	*Palaic*
No. of Words	108	92	80	71	50

TABLE 3: Total of similar words with Linear-A by language (vowels added).

Furthermore, the most similarities between Linear-A and other languages can be found in two-syllable and three-syllable words, which remains as the same observation with the previous comparison (Table 4). Five-syllable words have no common word, while words with four-syllables have only few words in common, mainly in the first three languages (i.e., Etruscan, Lycian and Hittite). In both comparisons, Luwian and Palaic remain the furthest away languages.

Syllables per word	**1**	**2**	**3**	**4**	**5+**	Total
Linear-A	4	370	380	184	152	1090
Carian	2	78	24	4	0	108
Etruscan	1	142	39	1	0	183
Hattic	12	89	8	0	0	109
Hittite	5	124	16	1	0	146
Luwian	2	58	10	1	0	71
Lycian	2	132	14	0	0	148
Lydian	4	65	11	0	0	80
Palaic	2	41	7	0	0	50
Phrygian	2	85	22	2	0	111
Thracian	2	80	10	0	0	92
Total	34	894	161	9	0	1098

TABLE 4: Words similarity per size of syllables (vowels added).

Most attempts at deciphering Linear-A are based on the etymological method, i.e., comparing the vocabulary of Linear-A with other target-languages to identify a potential affinity, despite the several problems arisen with this approach (Salgarella, 2022). Yet, considering the extent of the etymological approach, the usage of the software tool described herein offers, through the above results, a quantitative indication about the target-languages that should be explored first. Moreover, it adds a machine-readable dictionary that is easily accessible and expandable, for the study of Linear-A corpus. In this respect, out of nine (9) databases of Linear-A, two notable and easily accessible online by the interested scholars include “SigLA” (Salgarella & Castellan, 2020) and the one by George Douros (n.d.). Although useful, well-organized, complete and even impressive, they cannot be regarded as machine-readable dictionaries, since they are not directly accessible for immediate processing, by a programming language (Braović et al., 2024). On the contrary, the lexicon herein can be immediately accessed by most programming languages, because it is implemented as a set of spreadsheets.

6. CONCLUSIONS & FUTURE RESEARCH

The presented herein software application aims at assisting scholars to study the potential relations of Linear-A to its contemporary languages, through an interactive digital environment. In this respect, a lexicon supports the whole process, being readily accessible both by scholars and by programming languages, since it is implemented as a set of spreadsheets.

Through the experimental usage of this software application, several quantitative relations have been recorded. Namely, the three main contemporary languages that appear to have more similarities with Linear-A are:

(1) Etruscan, (2) Lycian, (3) Hittite.

If scholars manage to use only one contemporary language for the interpretation of the entire Linear-A’s texts, and this translation has a meaning, then we have the proof that indeed Linear-A renders this particular language. Otherwise, Linear-A may render more contemporary languages, if we have inscriptions that can be interpreted through a single contemporary language per artifact. The latter case cannot be regarded as paradox, since Linear-A script was mainly used for commercial purposes between the Minoan Crete and the islands and lands in proximity, with which the Minoans had exchange of products.

Besides facilitating the comparison of Linear-A’s vocabulary to that of other target-languages, the educational use that our software tool can also facilitate allows scholars, researchers and students of Archaeology, Philology, Comparative Linguistics and anyone interested to learn and understand Linear-A. Furthermore, it can be used for the translation and interpretation of the known texts that have been found in tablets and other artifacts, while, additionally, it is easily expandable towards two directions: firstly by incorporating more target-languages in its lexicon, for further study, and secondly by increasing the existing data, if new archeological discoveries allow so, in the future.

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