



Research Paper

A Software Application for Enquiring the Affinity of Anatolian Languages

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ABSTRACT: In this paper, a software application is presented, aiming to enquire the linguistic affinity of Anatolian languages between them. The Anatolian languages is an extinct branch of the Indo-European language family, spoken in Ancient Anatolia, the period of focus herein being between the 16th and the 5th centuries BCE. The software application is based on a novel searching method, called “syllabic grouping”, which attempts to provide a searching criterion that allows the discovery of relations between words of similar form in different languages. The search-algorithm processes a database of seven languages, implemented as spreadsheets. The results of this Natural Language Processing application, as presented and commented herein, are somewhat different from the traditional views, considering the comparison of the different vocabularies.

KEYWORDS: Anatolian Languages, Natural Language Processing, Digital Humanities, Lexicon, Linguistic Software Engineering

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I. INTRODUCTION

The Anatolian languages are part of the Indo-European Language family, spoken in Anatolian area from the 3rd millennium BC. The known languages of the era attested in tablets are Hittite, Palaic, Luvian/Luwian, Lycian, Lydian, Carian. Those languages were extinct by the late Roman or early Byzantine period at the latest [1]. Languages have the power to provide vital clues about history as genes do for human. How each language is related to another one, especially if they coexisted in the same era, appears whether the people of those countries where the language was spoken or written had any kind of relation such as commercial ones [2]. For example, the Anatolian languages family, even though is most profoundly studied, cannot be clearly stated which languages were similar to each other or whether they coexisted in the same era. The known and accepted relations between them until now are the followings.

The Hittite language, which is the most known and significant of Anatolian languages that are part of this extinct Indo-European languages family was mostly related with Carian, Luwian, Lydian, Lycian, and Palaic. It is mainly cited in the 30.000 cuneiform tablets or fragments of those preserved in the archives of the Hittite capital city Hattusa. Most of them are part of the Hittite empire (c. 1400–c. 1180 BCE) [3]. Palā, Luwīya, and Hattusa formed the three major Anatolian provinces of the Old Hittite kingdom. That means Palaic, Luwian and Hattic languages formed the three major languages of the Anatolian provinces of the Old Hittite Kingdom.

The Palaic language was spoken mainly in northern Anatolia. It is believed that is one of the four primary sub-divisions of the Anatolian languages, alongside Hittite (central Anatolia), Luwian (southern Anatolia) and Lydian (western Anatolia). The Palaic language, is shown as *palaumnili* ‘language of the Palaite’ in Hittite cuneiform texts and was spoken in the region of Palā in northwest Anatolia from the 2nd millennium BCE. Evidence of the language appear in a few liturgical fragments from Hattusa that were dedicated to the cult of the Hattian god Ziparwa. Palaic was surely extinct as a spoken language by the 13th century BCE. Emil Forrer in 1922 was the first to refer the Indo-European character of Palaic language [4].

The Luwian language was spoken in southern Anatolia and Hittite provinces near northern Syria of today. Whether or not it was spoken is still under research, cause of the various writing systems that exist for this language. Cuneiform Luwian refers to the language recorded in the Hittite cuneiform archives from Hattusa; it is found in ritual passages and loanwords throughout the Hittite texts of the 16th–13th centuries BCE [4].

The Carian language was spoken in Caria, which was an ancient district of southwest Anatolia. Egypt is the main source of findings that cite Carian, where mercenaries of Caria were in the service of the pharaohs from the 7th to 5th centuries BCE and left behind more than a hundred tomb inscriptions. Caria itself has yielded a limited number of texts, dated roughly to the 6th through 4th centuries BCE. In 1981, Egyptologist John Ray successfully analyzed Carian scripts from tomb inscriptions of Carian-Egyptian mercenaries. The long-held suspicion that Carian is an Indo-European language of the Anatolian group has at least been confirmed by the appearance of such features as an -s suffix forming patronymics and the relative pronoun xi [5]. Carian is closely related to Lycian and Luwian, although they are not direct descendents of Luwian [6].

Lycian language is the language of southwestern Anatolia in the 1st millennium BCE. The Lycian alphabet was related to the Greek alphabet. Most of written Lycian are manifested in inscriptions on coins and tombs, as well as some longer texts of a historical nature. In 1945, linguist Holger Pedersen published a synthesis that proved conclusively that Lycian belongs to the Anatolian branch of Indo-European languages and indicated a relationship of Lycian with Hittite [7]. This conclusion was slightly modified when Franz J. Tritsch (in 1950) and, later, Emmanuel Laroche showed that Lycian should be more specifically compared to Luwian. It is now known that Lycian shares many features with Hittite, Luwian, and Lydian, although crucial divergences from each of these languages establish it as an independent branch of the Anatolian subgroup [8].

Another language of the family was Lydian that were spoken in western Anatolia in the 1st millennium BCE. This language is attested in plenty of texts that were found in the ancient capital of Sardis. They are mainly consisted of decrees and epitaphs of the 5th and 4th centuries BCE and a few in the early 7th century BCE. Early results concerning Lydian were reached using a strictly combinatorial method, described in a conclusive article by Piero Meriggi on the Indo-European character of Lydian (1936) [3]. In 1959, linguist Onofrio Carruba proved that Lydian has the same feminine gender as the rest of the languages of Anatolia. From the grammar of the language, it was proved that it belonged to the same subgroup as Hittite, Luwian and Lycian language, with some differences off course from its nearest relatives. In the early 20th century there was limited research in order to have more details [9].

The Etruscan language was spoken in Italy from 700 BC to 50 AD. It has been considered part of the Tyrsenian languages family that also includes the Lemnian language of the Aegean and the Rhaetic language of the Alps [10]. Although Etruscan had been considered an isolated language, various suggestions exist, relating it with other language families. Regarding the topic of the present study, a plethora of linguistic evidence relates Etruscan to the Anatolian languages' family, as presented by Woudhuizen [11], Szalek [12] and Thomopoulos [13]. Therefore, this possible relation has been investigated in terms of vocabulary.

II. PREVIOUS THEORIES ON ANATOLIAN LANGUAGES

Linguists have claimed that there is a various degree of relations between Anatolian Languages. According to comparative linguistics, even though they group some languages as of the same origin, not all of them are related to the same extent. In Kim [14], Luwian and Lycian are related, Hittite stand alone, while the rest (i.e., Carian, Lydian, Palaic and the later Pisidian not studied herein) seems to form a subgroup. In other approaches, Carian is classified in the family of the so called "Luwic" group. However, most of the Carian inscriptions are mainly graffiti with laconic context and have been found mostly in Greece and Turkey. This doesn't help the linguists to categorize it, but it has close relations with the Anatolian family as the Carian people were mostly the mercenaries in the ships of the Minoan kings of Crete [15]. The Hittite language is mainly related to Luwian and Palaic languages, which were languages spoken in the Hittite Kingdom [16]. The Lydian language was also part of the Anatolian branch of languages and appears to have more common elements with Lycian and Etruscan languages.

The Etruscan language, according to another study, is more relevant to Luwian, Carian, and Lycian languages [17]. On the one hand, it is considered that the Etruscan people originated from Lydia in Asia Minor and had migrated after 1000 BCE in today's region of Tuscany. On the other hand, other researchers assume that the Etruscan culture was developed in Italy and had simply commercial relation with Minoan Crete [18].

III. METHODOLOGY

In order to be able to compare Anatolian languages, it was decided to use the technique of syllabic grouping, 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 graphemic matching is described through simple examples that demonstrate its future potentials [19].

Lexical cognates are terms with the same etymological origin but that may or may not have the same form or meaning across languages [20]. As an illustration, the Latin term "corps" remained the same in English, French, and Dutch, but was transformed to "corpo" in Italian and Portuguese, "cuerpo" in Spanish, "corp" in Romanian, "korps" in German, etc. Finding cognates is a fundamentally important task in historical/comparative linguistics, since it provides a means of learning the relationships between various languages, which in turn helps to create a linguistic "phylogeny" or family tree. The reconstruction of Proto-Sapiens, the putative language used by the homo-sapiens group of people that fled Eastern Africa 50–70 thousand years ago and colonized the entire world, has been proposed using analogies. According to the theory of "monogenesis", all human languages originate in Proto-Sapiens [21].

Deciphering ancient scripts to reveal undiscovered or extinct ancient languages is another use of cognates from Digital Humanities. With the aid of a successful application, it was possible to automatically decipher Ugaritic, a language from the Western Semitic family that dates to the 14th century BCE and was written in cuneiform consonantal script. Due to Ugaritic and Hebrew's shared linguistic characteristics, the decipherment was successful [22]. Similar results can be obtained from Linear A script, which may represent one or more unidentified ancient and extinct languages [23]. It had been utilized during the Bronze Age (second and third millennia BCE), mostly in Minoan Crete but also in other regions of the Aegean Archipelago and beyond. In this respect, a software application is being developed for assisting the learning/study and decipherment of Linear A [24]. Part of this system is a computational tool that facilitates the discovering of Linear A's cognates in several other contemporary languages, presented next.

The observed existence of a core group of consonants, common in the numerous cognates, is the essential idea of the computational tool for cognate discovery. Looking at the word "corps" from the previous example, the core group of consonants is composed of the letters "c," "r," and "p," which are present in almost all cognates and in the same sequence in each word. Due to the final consonant's language-specific ending (like in declension), depending on the context or language, the last consonant may be removed. Since vowels are generally more subject to phonetic change [21], the "core consonantal form" (CCF) that remains for the cognates of "corps" is CRP. It is also necessary to perform a second stage of "graphemic normalization" to take into consideration the German "korps" that possess the CCF of KRP. In order to obtain the "normalized" CCF (NCCF) of CRP, the German grapheme "K" must be matched to the grapheme "C", based on their similarity in phonetics (the contrary is also feasible, depending on the matching convention of the designer/engineer). Thus, when searching, words are replaced by their NCCFs, and words that are returned and have a similar NCCF are prospective cognates that should be further investigated. The graphemic normalization is conducted according to the following table of "syllabic grouping" (Table 1).

Table 1: Syllabic Grouping

Original	Matched	Original	Matched
A	A	E - I	I
Θ	A - E	O - U	U
D - T - Δ - Θ	D	W	W
B - F - P - V	B	L - R	L
C - K	C	M	M
G - Q - X - Γ	G	N	N
H - J	∅	S - Z	S

Table I was created based on the graphemic/phonetic similarities and correspondences found between words in the Linear A script of unknown language(s) and those in the Linear B script (Greek). In the odd columns of Table 1, the original alphabetic graphemes (transliterated from the current syllabary) that reflect the corresponding phonetic values are grouped together, as it has also been noted that certain phonetic values belonging to the same category (e.g., dentals, labials, palatals, etc.) may be interchangeable between scripts and/or reproduced languages. For example, all dental graphemes {D, T, Δ, Θ}, whenever they occur in words, are conventionally assigned to the first of them {D} (see 2nd column of Table I) and replaced by it in the NCCF of the edited word. In this case, the same syllable grouping is also done for vowels (see the top two rows of Table I), forming the "normalized core graphemic form" (NCGF) of words. Consequently, the possible affinities of a language with other languages can be investigated, based on the corresponding NCGF of their words, which are stored in a database.

IV. THE DATABASE

Anatolian languages are known to have common elements and relations between them, as they reflect the exchange of products during Minoan time. The last language to be related is Etruscan. However not many agree with this mindset. By creating a database which contains all the known Anatolian languages of the era and using the syllabic cognates method to compare words between languages, we can prove they indeed had common elements and roots.

Firstly, the words of every language were divided by the number of cognates, and they were categorized in an excel sheet. Afterwards, using the linguistic affinity of some consonants, we were able to transform (e.g.) labials between them, in order to test if there were any relations between those words and that consecutively would prove that they belonged to a common language family. Based on a new algorithm that has been tested in Anatolian Languages, it is demonstrated how indeed they form a language family, and how this notion will be later extended in Linear A.

The languages attestations of that era were mainly used for commercial reasons and that is why there are big and small numerical aggregates that describe mainly the group, number and species of products, exchanged between people of the Minoan era. We have for example a list that says that the X person brought 5 “puto” pigs. (where *puto* meant “total”). However, we have cases with bigger aggregates that described the total of products came or bought by each area, like Phaistos, or Aghia Triada, which were ancient cities or places during the Minoan period of Crete.

As groups of consonants in Linguistics we use herein: Labials, Nasals, Dentals, Palatals, Velars, Liquids, Sibilants and Alveolars. As a result, when the algorithm goes to the words that have two syllables, it will start to search in which languages of the Anatolian family there is this combination. The result for this specific example is that similar words exist in Carian and Etruscan language. For example, the word “feet” is pa-ta in Hittite and pe-de in Lycian, both having the NCGF of BD (Table 2). The same NCGF (BD) has the word “place” in Carian, Etruscan and Lycian (Table 2).

Table 2: Some NCGFs for Anatolian languages

NCGF	Transcription		Translation	Language
	Alphabetic	Phonetic		
BD	pa-ta-	pata	foot, leg	Hittite
BD	pede	peðe	foot	Lycian
BD	pða-	p ^h da	place	Carian
BD	puθs	puθs	place	Etruscan
BD	pddēn-	pððēn	place, precinct	Lycian
BD	pddât-	pððât	place	Lycian

Another example is the word “heavy” which in Luwian is su-wa-ru, while in Palaic the same combination of syllables means “full”, which is quite close in meaning (Table 3).

Table 3: The NCGF “SWL” in Luwian and Palaic

NCGF	Transcription		Translation	Language
	Alphabetic	Phonetic		
SWL	šuwaaruš	šuwāru-	heavy	Luwian
SWL	šu-wa-ru-	šuwāru-	full	Palaic

In the last example, the word “father” in Hittite is a-tas, while in Etruscan the word A-ta means grand-father (Table 4). Both have the NCGF “AD”.

Table 4: The NCGF “AD” in Hittite and Etruscan

NCGF	Transcription		Translation	Language
	Alphabetic	Phonetic		
AD	Ata		grandfather	Etruscan
AD	at-ta-aš	attaaš	father	Hittite

V. RESULTS

According to our research with the method of syllabic comparison and family of consonants in the known words of Anatolian languages, the three groups of languages that are more similar to each other considering their vocabulary are (Fig. 1):

1. Palaic – Hittite – Luwian
2. Lycian – Lydian – Carian
3. Etruscan, placed between both previous groups.

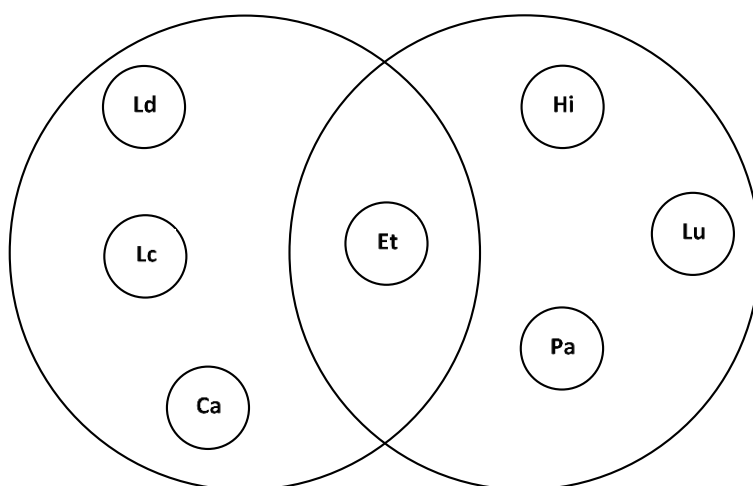


Figure 1: Anatolian languages affinity subgroups

The results after using the syllabic comparison method showed that between the languages of Anatolia indeed some common words exist, in languages that were until now related and in languages that until now had no relation, and they were spoken in different eras and areas. These relations regarding vocabulary, are presented in Table 5.

Table 5: Number of cognates across Anatolian languages

	Carian	Etruscan	Hittite	Lycian	Lydian	Luwian	Palaic
Carian	382	9	4	14	3	6	3
Etruscan		730	10	11	11	4	7
Hittite			685	6	7	15	17
Lycian				579	14	8	4
Lydian					397	4	3
Luwian						254	13
Palaic							196

In Table 5, the numbers in the diagonal cells (highlighted) denote the size of a language’s vocabulary [25], e.g., the Carian dictionary contains 382 words; while the rest of the numbers denote the cognates between two languages, e.g., there are nine (9) cognates between Carian and Etruscan. Considering every single language:

- The Carian language has 9 cognates (common/similar words in form and meaning) with Etruscan; 4 cognates with Hittite; 14 cognates with Lycian; 3 cognates with Lydian; 6 cognates with Luwian and 3 cognates with Palaic. According to these results, the Carian language was mostly related with the Lycian language.
- The Etruscan language has 10 cognates with Hittite; 11 cognates with Lycian; 11 cognates with Lydian; 4 cognates with Luwian; 7 cognates with Palaic and 9 cognates with Carian. As a result, we can notice that there was a big relation of the Etruscan language with most of the Anatolian language family with the least close relation to be the one with Luwian language. And in fact, with Lycian and Lydian they had the exact same number of common cognates.

- The Hittite language has 6 similar cognates with Lycian; 7 with Lydian; 15 with Luwian; 17 with Palaic; 10 cognates with Etruscan and 4 cognates with Carian. As a result, a strong relation can be established between Etruscan Palaic and Luwian language to be the most relevant and Carian the least.
- The Lycian language has 14 cognates with Lydian; 8 cognates with Luwian; 4 cognates with Palaic; 6 cognates with Hittite; 11 cognates with Etruscan and 14 cognates with Carian. As a result, the greater relation of Lycian is with Lydian, Carian and Etruscan language. The more distant relation was with Palaic.
- The Lydian language has 4 cognates with Luwian; 3 cognates with Palaic; 14 cognates with Lycian; 7 cognates with Hittite; 11 cognates with Etruscan and 3 cognates with Carian. As a result, it is mostly related to Lycian and Etruscan languages. Carian is the most distant language from Lydian.
- The Luwian has 13 cognates with Palaic; 15 cognates with Hittite; 6 cognates with Carian; 4 cognates with Etruscan; 8 with Lycian and 4 cognates with Lydian. It is clearly noticed that it has the biggest similarities with Hittite and Palaic and the more faraway relation with Etruscan and Lydian.
- The Palaic language has 13 cognates with Luwian; 3 cognates with Lydian; 4 cognates with Lycian; 17 cognates with Hittite; 7 cognates with Etruscan and 3 cognates with Carian. From this we can see that Palaic language is related mostly with Hittite and Luwian and least related with Carian and Lycian.

These relations (i.e., number of cognates per language pair, as denoted by the number of the edges of the graph in Fig. 2) have been also depicted diagrammatically, in the graph of Fig. 2, where “Hi” is for Hittite, “Pa” for Palaic, “Lu” for Luwian, “Ld” for Lydian, “Et” for Etruscan, “Lc” for Lycian and “Ca” for Carian.

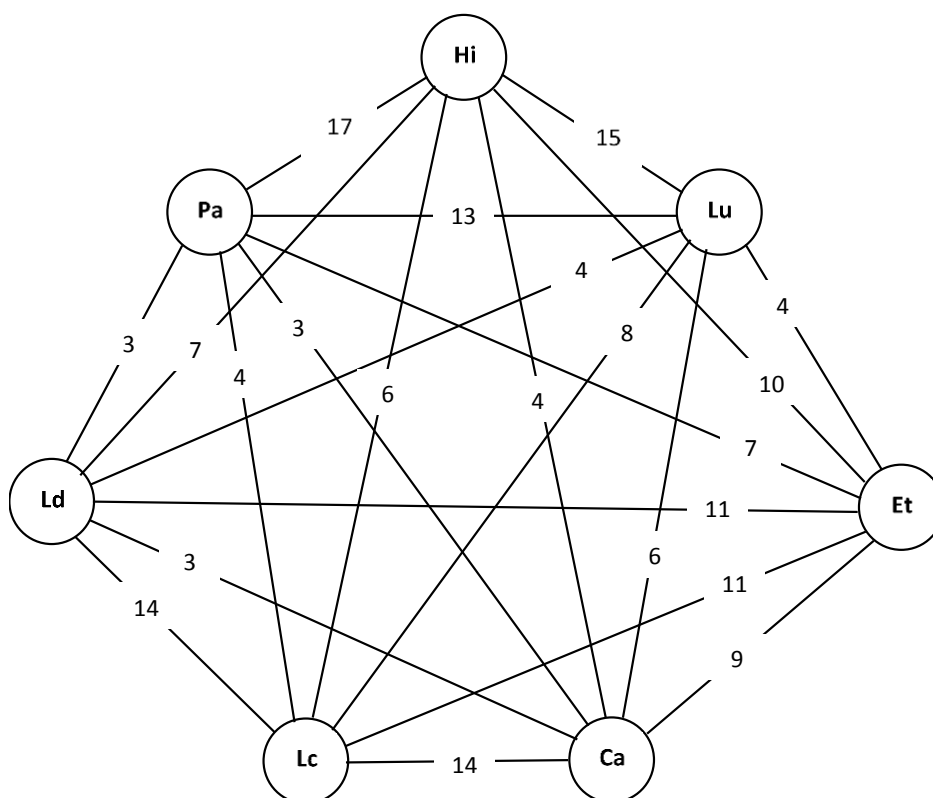


Figure 2: Number of cognates per language pair

This affinity is also expressed in percentages, regarding the respective size of dictionaries (Table 3). For example, the 9 cognates between Carian and Etruscan (Fig. 2), correspond to 1.23% of the existing Etruscan vocabulary and to 2.36 of the Carian vocabulary (Table 6). From the percentages of Table 6, a Comparative Relative Proximity Ratio (CRPR) per language pair has been calculated, as presented in Table 7. Taking Carian

as an example, the largest percentage of cognates in Table 6 is with Lycian (3.66). This affinity is the reference point of proximity between Carian and the rest of Anatolian languages (see Table 7: Carian-Lycian = 1.0). This reference point is then divided by the percentage of every other language, e.g., for Carian-Etruscan = $3.66/2.36$ (see Table 6) = 1.6 (see Table 7). The smallest the value of CRPR is between two languages, the closer they are regarding vocabulary.

Table 6: Percentages regarding the size of dictionaries

	Carian	Etruscan	Hittite	Lycian	Lydian	Luwian	Palaic
Carian		2,36	1,05	3,66	0,79	1,57	0,79
Etruscan	1,23		1,37	1,51	1,51	0,55	0,96
Hittite	0,58	1,46		0,88	1,02	2,19	2,48
Lycian	2,42	1,9	1,04		2,42	1,38	0,69
Lydian	0,76	2,77	1,76	3,53		1,01	0,76
Luwian	2,36	1,57	5,91	3,15	1,57		5,12
Palaic	1,53	3,57	8,67	2,04	1,53	6,63	

Table 7: Comparative Relative Proximity Ratios

	Carian	Etruscan	Hittite	Lycian	Lydian	Luwian	Palaic
Carian		1.6	3.5	1.0	4.6	2.3	4.6
Etruscan	1.2		1.1	1.0	1.0	2.7	1.6
Hittite	4.3	1.7		2.8	2.4	1.1	1.0
Lycian	1.0	1.3	2.3		1.0	1.8	3.5
Lydian	4.6	1.3	2.0	1.0		3.5	4.6
Luwian	2.5	3.8	1.0	1.9	3.8		1.2
Palaic	5.7	2.4	1.0	4.3	5.7	1.3	

According to the CRPRs of Table 7, the languages affinity of Fig. 1 has been calculated. It has to be noted though that the number of cognates is very small compared to the size of the dictionaries [25].

VI. CONCLUSION

According to our research with the method of syllabic comparison and family of consonants in the known words of Anatolian languages (Table 7), the groups of languages that are closer to each other, regarding merely their vocabulary, are:

1. Hittite – Palaic –Luwian
2. Hittite – Etruscan
3. Lycian – Etruscan – Lydian
4. Lycian – Etruscan – Carian

Seemingly, the previous linguistic theories on the affinity of Anatolian languages to each other (see relevant chapter, above) are not verified considering their vocabulary. Especially regarding Etruscan, this language is not as close to Luwian as claimed by Woudhuizen [11], but it rather verifies the historical narration of Herodotus that at least some Etruscans came from Lydia [26].

The Etruscan civilization is considered to had been mitigated in Toscane and it has been found also a proof in the DNA results that states the relation it has with Anatolian area languages [17]. It is also noticed in the two paintings of Fig. 3, which come respectively from Minoan and Etruscan civilizations, that both have the same technique and philosophy [27]. However, according to some linguists, there were humans that supposedly had no knowledge of Minoan civilization. But there are many findings in recent years and in our analysis that show how old the Etruscan civilization was and how they were influenced by the Minoan Crete, because it is said that they left from Limnos. The Minoan civilization had commercial relations with all the Aegean, and as a result we can see the exact same subject, the exact same faces, same colors and even same clothes and technotropy in a way that there is no chance the Etruscan painter had visited Crete and have seen it in the Minoan palaces. Since, according to their placement of Historians, Etruscans appeared 1000 years after the Minoans. Either this technique passed on generations, and someone saw it while traveling and painted it, or the

Etruscan civilization coexisted with the Minoan one [28], as suggested herein by the observed linguistic affinity of the Etruscan language to other Anatolian languages contemporary to the Minoan civilization.



Figure 3: On the left, a saffron-gatherer woman from Thera Island (Late Bronze Age); on the right, a girl dancing with incense burner on her head from Tarquinia (6th century BCE)

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