A Semantic Index for a Dongba Script Database

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Abstract. Dongba script is a pictographic writing system still in use in South-West China. The Dongba dictionaries provide valuable resources and should be used in complete synergy to build up a character repertoire. A semantic index with the pictographic radicals, along with other kinds of indexes, is necessary for an ideographic writing system such as Dongba script, while the studies on Dongba radicals are at a preliminary stage. This semantic index also contributes to show that similar markers arose in a logographic system.

1. Introduction

The Dongba script has been enlisted in the World Memory Heritage by the Unesco in 2003. It is a unique pictographic writing system, still in use today.[1] Its pictographs are used to convey in their own way, basically through semantic-visual stylized signs and much less through phonograms, the Naxi thought and language (a member of the Yi, aka "Loloish," branch of the Tibetan-Burman language family), see Ramsey (1987, pp. 249–250). With the recognition of this writing system, many other pictographic scripts have been brought into light. Among other places, South-West China shows to be a cradle of pictographic writings, e.g., Ersu Shaba script (Sun, 1982), Pumi Hangul script (Song, 2010), Muya Sujowu script (Liu and Huang, 2013), Namuzi Pabi/Pazi script (Wang and Wang, 2013), Lhoba Niubu script (Zhao, 2014), etc.[2] Scholars pointed out that the development of early writing systems can be reconstructed through the analysis of these scripts belonging to ethnic groups (Song, 2010).

Many "scribal models" around the world share similar techniques in conveying information. For example, the so-called Dakota winter counts [Lakota Sioux lineage groups, U.S.] (Howard), Mi'q-m'aq

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1. Revised Proposal for Encoding Naxi Dongba Pictographic Script in the SMP of the UCS, 2011.

2. More scripts can be found in Zhao (2013).

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(= Micmac) [Atlantic seaboard / Quebec North-shore, Canada], and Rongorongo [Rapa Nui / Easter Island; modern Chilean territory], seem inventories of certain dates. Kuna (= Cuna) Mola [San Blas Islands on the Atlantic side of Panamá, with minor settlements in the Chucunaque region of the Darien forest, near the Colombian border], used to be body painting patterns.

These scribal symbols show different stages of the development of writing systems. While most pictographic scripts are strictly attested in specific documents, such as indigenous religious manuscripts, calendars, or songs (e.g., Poya Script of Zhuang People in Guangxi Province, China), Dongba script is used also to transcribe local language besides Dongba scriptures. Moreover, Dongba script possesses a greater number of glyphs, if compared to the others.

Moso/Na People 'live' at the border between orality and literacy.[3] The correspondence between the Dongba glyphs and the Moso/Na language they transcribe is different from the one between well-known mature writing systems and their related languages, such as Chinese, Japanese, Latin, Sanskrit, Arabic, etc. Traditionally, Dongba glyphs are used for scriptures. In these works, the pictograms transcribe only the keywords of a verse in Dongba chants (Fu, 1982, p. 6; Wang, 1988, p. 124; Yu, 2009, p. 19). Dongba priests can read out the complete verses from the scriptures, according to the oral versions of the texts learnt by heart (Li, 1997, pp. 70–71).[4]

Dongba writings has also undergone 'evolution'. Dongba glyphs have been used to transcribe secular documents (notation of accounts, land contracts, letters, etc.) in which they are utilized as phonetic loans to write down each syllable of a sentence (Yu, 2003, pp. 252–282; Yu, 2008, pp. 124–250). In the contemporary world, Dongba pictographs are applied to transcribe couplets, modern vernacular language, and even for-

3. "Moso" is the old appellation of this ethnic group living along the Jinsha River, the main branch of the upper stream of the Yangtze River. The literature recordings of this ethnic group can be traced back to the Jin Dynasty (265–420 AD; Chang, 1987, p. 210). It was still spotted in documents during the period of the Republic of China. On the other hand, "Na" is the Romanized word of the shared syllable of their endonyms. During the nationality recognition conducted by China in 1950s, the western branch of Moso People has been recognized as "Naxi" People, according to their endonym /nɑ˧˩ʂi˧/. According to language documentation studies, the other branches share the similar morphological structure of their endonyms: the syllable "nɑ" followed by the word for "people". The syllable "nɑ" is homophonic to the word meaning "black, big". Therefore, some scholars use "Na/Naish" People to refer to this ancient ethnic group (Jacques and Michaud, 2011). According to ISO 639–3, the dialects of Moso/Na languages are assigned to two different codes: "nxq" for Naxi and "nru" for Na.

4. The eastern branch remains still an oral community. Their writing system includes a limited number of pictographs which are only known by the Daba priests (Song, 2003; Xu, 2017a).

eign brands (e.g., "Starbucks," cf. Poupard, 2019, p. 54). Dongba priests can also apply their writings to transcribe IPA (cf. Zhao, 2013, p. 76). According to the framework of writing systems developed by Gelb (1952, pp. 190–194), Dongba script should be categorized as a semasiography used as an identifying-mnemonic device, which is undergoing the change into phonography.

The present study focuses on a crucial first step to digitize Dongba script: the construction of a font database of Dongba glyphs. The author provides an in-depth analysis of the Dongba radicals which lays a foundation for a font database. A font database includes a comprehensive collection of Dongba glyphs and sets up a semantic index that can be compared to radicals in Chinese characters.

2. The Development of Dongba Digitization

E-Dongba is the first keyboard for typing Dongba pictograms (2001–2020). This keyboard can input Dongba pictographs through either semantics or Naxi *pinyin*. Chinese and English translations of each Dongba character are embedded into the system. The lexical database of *E-Dongba* is based on Fang and He (1981).[5] The Dongbafont implemented in *E-Dongba* includes 1,561 Dongba hieroglyphs and 661 Geba scripts, along with 50 International Phonetic Alphabet (IPA) characters for the Naxi language.

Several other attempts to type in Dongba pictographs were produced (see in Table 1). Among the five patents, three depend on semantics and two on the shapes of the characters. These keyboards aim at enabling users not knowing much about Dongba pictographs to type in these characters. The action of typing in Dongba pictographs according to their meanings involves the issue of translation. To key-in Dongba pictographs according to the composition of the characters requires a detailed analysis of several aspects of each character (components, strikes, crossing points, etc.), which could also be challenging.

Besides the virtual keyboard, several designs of Dongba script were published open-source, e.g., 遊トンパ, 遊トンパ年賀 (Kojima, 2002–2004). They are self-designed fonts in TrueType format, together with a character table displaying limited graphs (215, which is about one tenth of the inventory of Dongba pictographs).[6]

As a foundation of a key-in system, a database of the characters needs to be settled. The Unicode encoding project aims at providing an inter-

5. Cf. The third official Unicode proposal N4043 (L2/11–178: 2) submitted in 2011.

6. There are three ways to input text in Unicode: by selecting characters from a table; by virtual keyboard; by converting data that exist in other encodings (Haralambous, 2007, p. 159).

Table 1. Patents of Academic Institutions

Title and Number	Publication	Institution
纳西东巴象形文字的分类拼意输入方法及其键盘 (CN1547094A) A Keyboard to Type Dongba Pictographs Based on Semantic Catergorization	2004.11	大理学院 Dali University
东巴文图元输入法及键盘 (CN101477408A) A Keyboard to Type Dongba Pictographs Based on Structures and Strokes	2009.07	大连民族学院 Dalian Minzu Institute
纳西-汉-英输入法的实现方法 (CN103677305A) A Naxi-Chinese-English Keyboard to Type Dongba Pictographs	2014.03	昆明理工大学 Kunming University of Science and Technology
基于图形拓扑特征进行识别的纳西东巴象形文字输入方法 (CN104866117A) A Keyboard to Type Dongba Pictographs Based on Graphic Topology	2015.08	北京科技大学 University of Science and Technology Beijing
纳西东巴象形文和中文的综合输入方法 (CN106055124A) A Naxi-Chinese Keyboard to Type Dongba Pictographs	2016.10	河南农业大学 Henan Agricultural University

national standard for computer processing of the Dongba pictographs, in order to facilitate an easier transmission of the data on the internet. The preliminary task of this goal is to settle down the number of Dongba characters and the unified forms of them. The script has a tentative allocation at U+1A800 to U+1ACFF. The related proposals, comments, and meeting records are chronologically listed on the website SCRIPTSOURCE.[7] A summary of the Unicode proposal progress is displayed in Table 2.

Table 2. Summary of Unicode Proposal Progress

Title (Year)	# ch.	Principles of Selecting	Order of Characters	Information of Characters
L2/00–048 (2000)	48	different syllables	alphabetic	column-row

7. The webpage of Dongba script: https://scriptsource.org/cms/scripts/page.php?item_id=entry_detail\&uid=lb7t8h9k6v.

N3425 (2008)	1203	A. exclude variants B. exclude most phonetic loans C. include only the stable compounds D. exclude Geba script	semantic (reference unclear, possibly *Naxi Dongba Guji Yizhu Quanji*)	serial number
N3442 (2008)	Geba signs should be included; lexical sources besides *Naxi Dongba Guji Yizhu Quanji* should be cross-checked; the characters should be assigned to tentative code points			
N3935 (2010)	1188	A, C, & D B. include only one phonetic loan	alphabetic (based on the Naxi Pinyin orthography)	English translation
N3965 (2010)	Naxi Dongba pictographs were "pre-writing" rather than a writing system.			
N4043 (2011); N4633 (2014)[8]	1188	A. exclude variants B. exclude Geba script	alphabetic (based on the Naxi Pinyin orthography)	English translation; character name (Naxi Pinyin transcription)
N4641 (2014)	provide details of each Dongba glyph, including: 1) glyphs in the Dongba script, 2) IPA transcription, 3) Romanized orthography, 4) Chinese gloss for each syllable, 5) English translation of each Chinese gloss			
N4877 (2017)	1572	Fang and He (1981)	semantic	character name (Naxi Pinyin transcription)
N4878 (2017)	2164	Li, Zhang, and He (1972)	semantic	character name (Naxi Pinyin transcription)
N4895 & N4898 (2017)	1188	the same repertoire as N4043	alphabetic	character name (Naxi Pinyin transcription); IPA transcription; gloss in both English and Chinese
N4895 (2017)	provide an explanation of how some characters can combine			

8. The proposal of 2014 remains the same as the 2011 one, with a supplementary file about the modern use of the Dongba script. The comments on N4043 (2011) remain the same as the ones in N3965, issued in 2010 (cf. N4060).

L2/18–321 (2018)	the repertoire of 1188 characters omitted many commonly used ligatures (onomastics); the records of polyphone and polymorphic characters; three popular methods of combination of Dongba graphemes: *combination of two ideograms attaching phonetic grapheme to a logograph adding a morphemic grapheme indicating the colour of the object*
L2/19–173 (2019)	what two-dimensional model will be used to present the script

3. A Semantic Index for a Dongba Script Database

3.1. The Notion of Dongba Radical

The latest Unicode Proposal arranges the Dongba glyphs following a phonetic order, the same as in Rock (1963). However, the semantic order strategy was the more popular criterion applied in Dongba dictionaries, such as Li, Zhang, and He (1972), Fang and He (1981), and Rock (1972). The 2,120 entries in Li, Zhang, and He (1972) were divided into eighteen categories. The 1,340 entries in Fang and He (1981) were divided into eighteen categories either. Rock (1972) contains fourteen categories of special vocabulary of Dongba culture, in addition to the basic vocabulary recorded in Rock (1963).

The idea substantiating Li, Zhang, and He (1972) and Fang and He (1981) is comparable to the strategy of some traditional Chinese dictionaries. For example, *Erya* 爾雅, a first surviving Chinese dictionary (pre-Qin Dynasty, cf. Karlgen, 1931, p. 49; Needham, Lu, and Huang, 1986, p. 191), which provided lexicographic guides to the Chinese characters of nineteen semantic categories. While Rock (1963) and Rock (1972) collect lexicons rather than characters.

As for a font database, *Shuowen Jiezi* 說文解字 (completed in 100 AD by Xu Shen) could be a model. In this dictionary, 9,553 Chinese characters (and other 1,163 variants) are categorized into 540 sections according to their major semantic components. The same categories are then catalogued according to the similarities of their forms.

The semantic order has been chosen partially due to the fact that the pictographic Dongba script consists of logographs. The characters with related meanings share the same graphemes, which are comparable to radicals in Chinese. A Chinese radical is a graphical component of a character "giving in a very general way something of the meaning of the character" (Chao 1948: 104–105). The notion was introduced by Xu Shen as "section" (" 部 ") in *Shuowen Jiezi*. It then became a standard in the compilation of dictionaries.[9] The term "radical" (" 部首 ") was first used

9. In this dictionary, Xu Shen established the six types of composition of Chinese characters (i.e., philological theory called "Liushu 六书 "). Similarly, there were dis-

in the *Kangxi Dictionary* 康熙字典 (Wilkinson, 2013, p. 74), which literally means "section heading" (Woon, 1987, pp. 147–148). The "radicals" are simplified categorizations of "sections". The number of radicals is 214 in the *Kangxi Dictionary*. The term has various other translated names, such as "semantic element," "key," "classifier," "determinative," and "signific," while "radical" is the most common (DeFrancis, 1984, p. 80).

At the current stage, none of the current key-in systems is designed according to radicals, while radicals can be highlighted among Dongba glyphs. As for the pictographic writing system, the radicals are closely related to the semantic categories of Dongba glyphs. For example, the glyphs in the category "astronomy" can be classified into fifteen groups according to their shared components:  "sky" (phonetic loan variant:  "mushroom"),  "sun,"  "moon,"  "month," "star,"  "star; bright,"  "the constellation of dzo (hybrid of yak and cattle)," "wind,"  "rain," "snow," "cloud,"  "dew,"  "lightening,"  "rainbow," and  "time".

The glyphs may contain more than one radical. For example, in the glyphs representing the four seasons, each glyph consists of the pictogram of the representative feature of the season: "wind," "rain," "crop on the ground" ("flower" is homophonic to the word "crop"), "snow," along with "three" and "month".

Table 3. Dongba Glyphs of the Three Months of Each Season

Glyph	Naxi Pinyin	Morphemes	Gloss
	/nioq seel hei/	spring-three-month	"three months of spring"
	/roq seel hei/	summer-three-month	"three months of summer"
	/chvl seel hei/	autumn-three-month	"three months of autumn"
	/cee seel hei/	winter-three-month	"three months of winter"

Yu (2003, p. 25) categorizes Dongba glyphs into three types according to their constructions: pictogram (" 单字 "), ligature (" 合文 "), and fixed-group glyphs (" 字组 "). The four glyphs of the seasons mentioned above, for example, are "fixed-group glyphs". Each component corresponds to one syllable of the designation of the glyph. Among

cussions on the composition methods of Dongba glyphs, e.g., Z. He (1976) highlighted seven categories, Fang and He (1981, pp. 56–72) analysed ten types of structures attested in Dongba pictographs, Wang (1988, pp. 44–54) proposed five basic methods, Zhou (1994) and Yu (2008, pp. 12–37) applied the *Liushu* Theory of Chinese to Dongba script.

these components, “wind,” “rain,” “snow,” “three,” and “month,” are pictograms, read as “spring,” “summer,” “winter,” “three,” and “month,” respectively, while “autumn” is a ligature, which consists of two pictograms (“flower” and “ground”), but is read as the word for “autumn”.

Zamblera (2018) is an initial work on a pictogram-based semantic index of Dongba writing.[10] The author categorizes the Dongba glyphs into “basic pictographs” and “complex pictographs”. A “basic pictograph” is defined as “made by one and just one iconographic unit (signifier) that conveys its meaning through its pictorial resemblance to the physical object meant,” while a “complex pictograph” can be divided into two sets: “composed units” and “fusion units”. Table 4 shows the correspondences among the terms defined by Yu (2003) and Zamblera (2018) for the different types of Dongba glyphs.[11]

Table 4. The Terms for Dongba Glyph Types

Yu (2003)	Zamblera (2018)
pictogram (“ 单字 ”)	basic pictographs
ligature (“ 合文 ”)	complex pictographs—fusion units
fixed-group glyphs (“ 字组 ”)	complex pictographs—composed units

The notion “basic pictograph” can be a counterpart of “radical” in the Chinese writing system, while “composed units” and “fusion units” are two major methods of composition of Dongba ligatures. In Dongba writing system, a radical can be an ideogram, a phonetic symbol, or a signifier.

The function of Dongba radicals are slightly different from those in the Chinese writing, due to the grammatological features of the Dongba script. The fixed-group glyphs consist of multiple pictograms to represent a word or phrase, which are read as multiple syllables. Therefore, a pictogram in a ligature functions as the radical (in the Chinese writing), while, in a fixed-group glyph, the pictograms are components, which can be linked to the radical index.

10. Description of this project, references, and other documentation can be found at the webpage “Naxi Dongba: Naxi People Culture and Dongba Tradition,” published by Stefano Zamblera in 2009. URL: `www.xiulong.it/4.0/Dongba/homeengl.htm`.

11. A description of these distinctive components can lead to the refinement of the two types of “complex pictographs,” as in Chinese “Liushu” Theory and other discussions about the composition of Dongba glyphs.

3.2. The Elicitation of Dongba Radicals

The present study provides an in-depth analysis of Dongba radicals based on Li, Zhang, and He (1972). The glyphs in the respective categories are ordered according to their semantic similarities. Some categories are organized more coherently to the shared component among the glyphs. Like in the case of the glyphs of the categories astronomy and geography, where each star or planet and each type of landscape, have a distinctive pictograph (cf. Appendix).

Conversely, some categories require more analysis in order to elicit the radicals. For example, the 341 glyphs (No. 230–570) in the category "humanity" generally share a basic grapheme indicating the notion of "human". However, one radical in itself would not be enough for searching purposes. Looking through the glyphs, it is possible to classify the words into nouns (natures and relations of human being) and verbs (movements of human being).

The noun section include 13 minor semantic groups: "human," ethnic groups based on standing figures like  "Guzo People" and  "Bai People,"  "human," "enemy,"  -1 "woman,"  "to sit (siting figures),"  "Indian,"  "manager,"  "dead,"  "body,"  "big,"  "open hair". The glyph "to sit (siting figures)" stands for a verb by itself. It has been listed in the noun section due to the fact that the glyphs connected with this radical are nouns, such as  "emperor,"  "guest," and  "lama priest". These glyphs are created by depicting sitting figures.

The verb section include 27 minor semantic groups, describing 15 types of movements:

1. movements of the legs:  "to jump,"  "to kneel,"  "to lean on,"  "to fall,"  "to tremble,"  "to run,"  "to step across,"  "to fold,"  "to get up";
2. movements of the arms:  "to lift,"  "to fly";
3. movements of excretion:  "to wee";
4. movements of the mouth:  "to speak";
5. movements of creeping:  "to crawl";
6. movements of the waist:  "to bow";
7. movements of the head:  "to hit with head";
8. movements of the hand:  "to paste,"  "to bring";
9. movements of bringing instrument:  "to bring knife,"  "to pull,"  "to chase";
10. movements of the eyes:  "to look";
11. movements of a people above an object:  "to ride";
12. movements of mind: "sad";
13. movements of woman: -2 "woman";
14. mutual movements between two people: "to fight";
15. movements of one people on another: "to beat".

In Zamblera (2018), Dongba pictographs are documented according to twenty-five semantic categories with 405 subcategories ("basic pictographs").[12] The references of this dictionary include Rock (1963), Rock (1972), Fang and He (1981), Li, Zhang, and He (1972), and two recent collections: P. He (2004) and Dragan (2005).[13] While the traditional dictionaries start from "astronomy," "geography," human related aspects, and, then, all sorts of animals, etc., Zamblera (2018) reorganized them according to an order that begins from "human" and proceeds to "deities," all sorts of animals, plants, etc. Moreover, "woman" has been distinguished as an independent category, in contrast to "man," in this new work.

The number of "basic pictograph" in each semantic category can be further studied. For example, according to my analysis based on Li, Zhang, and He (1972), there are 38 radicals belonging to "body parts of human," while in the index plate of Zamblera (2018) their number is 15. By comparing Zamblera's and the author's results, thirteen radicals result to be the same. Among the two Zamblera's basic pictographs not included in my analysed radicals, "body" and "hair" are not recorded in the fourth section "parts of human body and their movements" in Li, Zhang, and He (1972). The word "body" is recorded in the third section "Humanity": No.265, 𐓏, /gv⊣/. The word "hair" is recorded in the ninth section "Food": No.1321, 𐓑, /ts'ɛ˥/ or /kv⊣ts'ɛ˥/. Cf. Li, Zhang, and He (ibid., pp. 25, 103). In contrast, "head" is a basic pictograph, incorporating "ear" and "nose" in Zamblera's plate. The other twenty-five radicals

12. Excerpt from Zamblera's text: "A. Man and his Occupations (4); B. Woman and her Occupations (4); C. Anthropomorphic Deities (16); D. Parts of the Human Body (15); E. Mammals (30); F. Parts of Mammals (66); G. Birds (11); H. Parts of Birds (22); I. Amphibious, Reptiles, etc. (16); K. Fish and Parts of Fish (1); L. Invertebrates and lesser Animals (12); M. Trees and Plants (20); N. Sky, Earth, Water (31); O. Buildings, Parts of Buildings (13); P. Ships and Parts of Ships (1); Q. Domestics and Funerary Furniture (4); R. Temple Furniture and Sacred Emblems (14); S. Crowns, Dress, Staves, etc. (10); T. Warfare, Hunting, Butchery (15); U. Agriculture, Crafts, and Professions (30); V. Rope, Fiber, Baskets, Bags, etc. (5); W. Vessels of Stone and Earthenware (4); X. Loaves and Cakes (6); Y. Writings, Games, Music (19); Z. Strokes, Signs derived from Tibetan, Chinese, Geba, etc., Geometrical Figures Circular, Rounded Curve, Triangle, Squared, Orthogonal (36)."

13. P. He (2004) collected 1,000 commonly used Dongba glyphs, presented in 24 semantic categories. The twenty-four categories (and their English translations) of P. He (ibid.): weather 天象, seasons 时令, geography 地理, direction and position 方位, plants 植物, birds 鸟类, beasts 兽类, insects and others 虫鱼, domestic animals 畜禽, human body 人体类, family and people 人物类, behaviour 行为类, religion 宗教, gods and ghosts 神鬼, labour 劳作, food and kitchen equipment 餐饮, housing and village 房舍, clothes 服饰, war 战争, tools and wares 器物, culture 文艺, modify 形容, state 状态, numbers and others 数词和其他词. Dragan (2005) recorded 1803 Dongba pictograms and three Dongba manuscripts translated into Serbian and one Serbian poem translated into Dongba verses.

not picked as basic pictographs in Zamblera's plate are not spotted in the character list of the Section D "Parts of Human Body" (Zamblera, 2018, pp. 56–59).[14]

Among the 38 radicals of body parts, six are "ligature radicals":  "one eye (cl.),"  "see," "tusk,"  "molar," "to think," and  "lung," while the other 32 are simple pictograph radicals. The ligature radicals are semantically connected with their corresponding simpler pictograph radicals. For example, "one eye (cl.)" and "see" are related to  "eye," "tusk" and "molar" are related to "mouth," due to the shared form, while "to think" and "lung" are related to  "heart".[15] The additional dots in "to think" (compared to "heart") are a commonly used indicator in Dongba writing, which means "something". These ligatures are considered radicals because they are used repetitively as entities to represent a morpheme in ligatures or fixed-group glyphs.

Table 5 shows the two sets of radicals attested in the category of plants.[16] The radicals in each line are semantically connected. There are 20 basic pictographs of trees and plants in Zamblera's categorization, while they are 49 in my analysis. These elicited glyphs can be classified into 11 groups, namely: "wood," "tree," "flower," "seed," "panicle," "thorn," "leaf," "spicy (n.)," "vegetable," "grass," and "bamboo".

The ligature radicals are highlighted in blue. For example,  "liquid medicine" belongs to the radical "flower" and it appears as a component in several ligatures, such as  "to give liquid medicine to spirits,"  "to mix," and  "to separate the herb and poison". Therefore, "liquid medicine" is picked out as a radical.

The two glyphs of "tree" and "firewood" are interchangeable, i.e.,: both  and ()can mean "tree" or "firewood". However, they should be distinct as two radicals. In the context of the form of a glyph, one pictograph is a tree standing and the other one is a tree lying. The glyphs containing these two components can be distinguished according to their pronunciations. Through a phonetic analysis, the meaning of the words, rather than the form of the components, will contribute to figure out the conditions of the "interchange" between these two pictographs.

Moreover, the glyph can be, in fact, analyzed as two radicals: -1 "wood," a general term for wooden objects; and -2 "tree," a general term for all kinds of trees. This divergence of the glyph "tree" is an addition to Zamblera's list, aiming at a more precise semantic segmentation of the tree-related glyphs.

14. The Dongba font used in the article is BabelStone Naxi LLC (published in May 2017). URL: www.babelstone.co.uk.

15. The glyph "mouth" is missing in the BabelStone Naxi LLC font list.

16. "Z." and "X." represent the surnames of the authors, and "gl." stands for "gloss". The uncertain glosses are marked in grey.

On the other hand, among the glyphs depicting all varieties of trees, it is possible to highlight two major patterns of the glyphs: five-branch trees and three-branch trees. Two of the prototypes are chosen as radicals: (1)  "chestnut tree"[17] and (2)  "willow". The fir tree has glyphs both with three branches () and five branches (). In general, the trees with stronger branches tend to be depicted with five branches (e.g., "oak" and "white birch") and the trees with thinner branches with three (e.g., "willow" and "camphor tree"). The three-branch pattern is also attested among the glyphs of thorny and herbaceous plants.

Table 5. Radicals of Plants

Z.  X.  -1 gl. wood	— broken	  () firewood	—  one trunk of wood		
Z. — X. -2 gl. tree	— pine tree	— cypress	— chestnut tree	— willow[18]	— () fir
Z.  X.  gl. flower	— beautiful	— liquid drug	— poison	 — turquoise; jade flower	 -flower-[19] sunflower
Z. — X. gl. seed	— pod				
Z. — X.  gl. panicle	— rice[20]	  wheat	— hulled barley	  millet	  amaranth
Z. — X.  gl. a kind of thorn	 thorn	— thorns	 — unknown		

17. This glyph is translated as "oak" in Rock (1963, p. 258).
18. "Willow" is a homophonic word of "enemy".
19. This radical is listed after the radical "flower," according to my current analysis.
20. "Rice" is a homophonic word of "to feed; human".

Z. —	—	—	—			
X. 						
gl. leaf	tobacco leaf	soybean	hemp			
Z. 	—	—		—		
X. 						
gl. cactus	zantho-xylum	ginger[21]	garlic[22]	perilla	prosperous	
Z. 	—	—	—	—		—
X.  , 						
gl. bracken	agar-agar	mushroom	melon	gourd	turnip (vegetable)	chives
Z. 	—		—	—		—
X. 				—		
gl. grass (generation; time)	sabaigrass	mug wort	medick (god of livestock; livestock; ruminant)	farges decaisnea fruit[23]	[thatch]	creeping wood sorrel
Z. —						
X. 		—				
gl. branched horsetail [banana]	bamboo					

The differences spotted in the two sets of radicals depend partially on whether to include the ligatures in the radical system or not, and are partially due to the format of the sources quoted for the elicitation of radicals. At the current stage, the author elicits repetitively-used ligatures as radicals for the semantic index of the Dongba Script database. Moreover, it is possible to highlight some features of these radicals helping to understand the early stages of logographic writing systems.

First among them is the variety in the form of a glyph. A word may be written through several variants. The word "rainbow" can be either written through a pictogram  , or , which is with an additional component "ground" () to indicate the location of a rainbow. It is also possible to use a phonetic loan to represent a radical. As attested in the category "Astronomy," the radical "mushroom" (/mol/) is an occasional substitution of the radical "sky" (/mee/), despite their different pronunciations: "a white chaos of the initial world" (No.19), "a black

21. "Ginger" is a homophonic word to "to throw".
22. "Garlic" is a homophonic word to "can" and "unit".
23. The glyph can be a phonetic loan of the word "time" (read as /dʐɯ^{31}/).

chaos of the initial world" (No.20). The direction of the glyphs is flexible; however, in some cases, it may indicate different meanings. For example, "fir" can be written either as  or  . The glyph  means "moon" when it is horizontal (), and "month" when it is vertical ().

A second element is the variety in the meaning of a glyph. One glyph may represent two semes and, therefore, two radicals. For example, the pictogram  can be a radical meaning of either "tree" or "wood". Moreover, it uses pine tree as the prototype of trees.

As a third aspect, the radicals may lie within the glyphs, and yet they are not used analytically. For example, the glyphs  "die" (No. 291) and  "lie down" (No. 306) share the concept of an individual lying down. However, there is not a single character in which only a figure of an individual lying down exists without indicators. For another instance, as mentioned, the glyphs of plants are often depicted by three branches or five branches. Nevertheless, there is not a glyph representing the general notion of three-branch plant or five-branch plant.

4. Latin Alphabets for Semantic Index

Multiple indexes, including phonetic index and radical index, are available in contemporary dictionaries (e.g., *Xinhua Dictionary*). Li, Zhang, and He (1972) provided indexes according to the IPA transcription and stroke numbers of Chinese glosses of each Dongba glyph. In other words, the alphabetic order and semantic order do not exclude each other.

For the character names, it is necessary to set up an orthography for transcribing IPA into Naxi *pinyin*. Naxi *pinyin* is designed for the standard Naxi language (Dayan dialect). Its Romanized letters can unify the various sets of symbols applied to transcribe Dongba glyphs pronunciations.[24]

However, Naxi *pinyin* needs to expand the inventory of notations in order to transcribe other dialects of Moso People. According to He and Jiang (1985, pp. 130–133), there is no contrast between voiced consonants and nasalized consonants, velar and uvular consonants, dental and retroflex stops. Therefore, nasalized consonantal initials, such as /mb/, /nd/, /ŋg/, are transcribed as /bb/, /dd/, /gg/, and no symbols for voiced consonantal initials exist. There are no symbols for neither uvular nor

24. Naxi *pinyin* orthography: /p/, /pʰ/, /b/, /m/, /f/, /t/, /tʰ/, /d/, /n/, /l/, /k/, /kʰ/, /g/, /ŋ/, /h/, /tɕ/, /tɕʰ/, /dʑ/, /ɕ/, /tʂ/, /tʂʰ/, /dʐ/, /ʂ/, /ʐ/, /ts/, /tsʰ/, /dz/, /s/, /z/, /i/, /y/, /æ/, /ɑ/, /o/, /u/, /v/, /ə/, /ər/, /iə/, /uæ/, /uɑ/, /uə/. As for a concise key-in convention, in N4877 and N4878, the letter /y/ stands for /ʏ/ in Li, Zhang, and He (1972), /a/ for /ɑ/, /e/ for /ɛ/, and /ə/ for /ʌ/.

retroflex consonantal initials since these phonetic values appear in conditional contexts. Nevertheless, minimal pairs of these consonantal initials exist in dialects of the Naish languages. For example, the contrasts between voiced initials and nasalized initials are attested in Li, Zhang, and He (1972), whose phonemic system reflects one of the western dialects in Ludian area. For another instance, Ruke People, an intermediate ethnic group of Moso People, distinguish voiced consonants and nasalized consonants and dental and retroflex stops. Ruke Dongba culture preserves rituals different from the Naxi Dongba context (He and Guo, 1985, p. 40). Dongba glyphs of Ruke People are recorded as an independent category in Li, Zhang, and He (1972, pp. 125–127). It is possible that the repertoire of Dongba pictographs will incorporate the Ruke Dongba pictographs transcribed in their phonemic system.

A more complete Latin alphabet for Naxi can be found on the "Omniglot" website, including symbols for both voiced consonants and nasalized consonants, edited by Michael Peter Füstumum and Wolfram Siegel.[25] Another main addition to the Omniglot version would be the retroflex initials. The author suggests inserting an "r" after the alveolar initials to stand for their retroflex counterparts. Letter "r" already exists in the current Latin alphabet for Naxi. It is used as an initial and, sometimes, trills, when it appears in the end of the syllable. Its usage to indicate a retroflex is not confused with its other functions and does not increase the number of letters in Naxi *pinyin*. Table 6 displays an expanded inventory of Latin alphabets for transcribing Naish languages. In comparison to the current Naxi *pinyin*, the modifications by Omniglot are highlighted in orange and the additions by the author are highlighted in green.

TABLE 6. Expanded Latin Alphabet for Naish Languages

Initials								
	stop				nasal	approx.	fricative	
labial	p[pʻ]	b[p]	bb[b]	nb[mb]	m[m]		f[f]	v[v]
dental	t[tʻ]	d[t]	dd[d]	nd[nd]	n[n]	l[l] (/ɾ/:[ɾ])[26]		
velar	k[kʻ]	g[k]	gg[g]	mg[ŋg]	ng[ŋ]		h[x]([h])	w[ɣ]([ʁ])
retroflex	tr[ʈʻ]	dr[ʈ]	ddr[ɖ]	ndr[ɳɖ]	nr[ɳ]	lr[ɭ]		
	affricate							
dental	c[tsʻ]	z[ts]	zz[dz]	nz[ndz]			s[s]	ss[z][27]
alveo-palatal	q[tɕʻ]	j[tɕ]	jj[dʑ]	nj[ndʑ]	ni[ȵ]		x[ɕ]	y[ʑ]
retroflex	ch[tʂʻ]	zh[tʂ]	rh[dʐ]	nr[ndʐ]			sh[ʂ]	r[ʐ]

25. Omniglot is an online encyclopaedia of writing system and languages built by Simon Ager. URL: https://www.omniglot.com/writing/naxi.htm.

Glides								
u[w]	i[j]							
Rhymes								
i [i]([ɿ],[ʅ]) ee[ɯ]	u[u] v[ɣ]	iu[y]	ei[e]	ai[æ]	a[ɑ]	o[o]	e[ə]	er[ɚ]
Tones								
-l: high	-: mid	-q: low	-f: rising					

5. Conclusion

The present study reviewed the achievements of the related project, including the implementations of key-in systems, fonts, and Unicode. The author has shown that a critical issue for the Unicode recognition of Dongba pictographs is to build up a comprehensive character list of this writing system. The dictionaries provide valuable sources on the Dongba script, from which a complete repertoire of Dongba glyphs can be elicited.

Most of the dictionaries apply a semantic categorization of Dongba pictographs, while a few use an alphabetical approach according to the phonetic transcriptions. The current semantic categorizations adopted by Dongba Dictionaries can be refined to a more detailed semantic index. Glyphs sharing one common pictograph and semantically connected with each other can be grouped as one subcategory.

The pictograph, the semantic component giving the core idea of the glyph, may correspond to the notion of "radical". Similarly to the early Chinese dictionary *Shuowen Jiezi*, a Dongba radical can be either a simple pictograph or a ligature. Each radical represents an entry for the semantic index. Such semantic index is conventionally implemented into the Chinese dictionaries.

The elicitation of radicals reveals the features of similar markers in pictographic writing systems. Through an in-depth examination of the shared components among Dongba glyphs, the author pointed out three types of 'loose' correspondences between their forms and meanings. Futher on, this research can also contribute to our understanding of how similar markers arose in mature logographic systems like

26. The phoneme /r/ is elicited from Li, Zhang, and He (1972). The phonetic value is [ɾ] as an initial. If this symbol is at the end of a rhyme, it indicates that the rhyme is a retroflexive vowel (ibid., p. XXIII).

27. Some dialects have nasalized voiced fricative initials. In those cases, it can be transcribed as /nss/.

Chinese logographs, Egyptian hieroglyphs, and Mayan glyphs (Handel, 2017, p. 3).

Other indexes, such as the alphabetical index of the phonetic transcriptions or English glosses and the number of strokes of their Chinese glosses, are not excluded by the semantic index. Moreover, multiple indexes could allow searching for glyphs through different channels. The major radical and related radical provide more paths to get to one glyph and, therefore, more analysis' options to the grammatological feature of one glyph. The alphabetical index depends on the Naxi *pinyin* transcription, which requires more Latin letters for a possible extended character list involving dialectal vocabularies.

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A. Dongba Radicals of Astronomy, Geography, Humanity, and Human Body Parts Based on Li, Zhang, and He (1972)

(The English terms are quoted from Li, Zhang, and He, 2001, pp. 419–421, translated by Tseng Chao-yueh.)

A.1. Phenomena Connected With Heaven 天文類 (15/117)

/mee/ sky	/nii/ sun	/hei mei/ moon	/hei/ month	/geeq/ star	/mbo/ star; bright	/ssiuq/ constellation of dzo (hybrid of yak and cattle)
/hai/ wind	/heeq/ rain	/mbei/ snow	 /jiq/ cloud	/nrur/ dew	/ciul/ lightening	/mi xil jjiq teeq/ rainbow
/rheeq/ time						

A.2. Geographical Phases 地理類 (13/112)

						
/ddiuq/	/njoq/	/jjoqnar-uallua/	/mboq/	lv	aiq	
ground	mountain	scared mountain	slope	stone	cliff	
						
/jjiq/	/tel/	/chv/	/heel/	/ree/	/lee ddraiq/	rurq
water	drop	nitrate	lake	road	field	corner

A.3. Human Natures, Relations, and Movements 人文類 (40/341)

A.3.1. 人文類-1: Natures and Relations (13)

						
/xi/	/ggv zzeeq/	/lei bbv/	/coq/	/rvq/	/mil/	
human	Guzo People	Bai People	human	enemy	woman	
						
/nzeeq/ to sit (sitting figures)	/jje aq/ Indian	/nzee/ manager	/shee/ dead	ggv body	/ddeeq/ big	/baq/ open hair

A.3.2. 人文類-2: Movements (27)

						
/co/ to jump	/ceel/ to kneel	/toq/ to lean on	/ndol/ to fall	/niol/ to tremble	/xa/ to run	/gua/ to step across
						
/sseel/ to fold	/dee/ to get up	/lvq/ to lift	/nziq/ to fly	/mbi/ to wee	/lerq/ to speak	/mbvq/ to climb
/ggvq/ to bow	/tail/ to hit with head	/bal/ to paste	/bol/ to bring	/hai/ to bring knife	/daiq/ to pull	/ndiul/ to chase

					
/liuq/	/nrai/	/nvl mei qil/	/mil/	/aiq/	/lal/
to look	to ride	sad	woman	to fight	to beat

A.4. Parts of the Human Body and Their Movements 人體類 (38/115)

						
/kv/	/mieq/,/nieq/	/pol/	/ddoq/	/hei/	/niil merq/	/nvl/
head	eye	one eye (cl.)	see	ear	nose	mouth
						
/beiq/	/nraiq/	/mgoq/	/hee/	/sal/	/lua baq/	/gei/
to spit	tusk	molar	teeth	breath	beard	neck
						
/laq/	/niil nii/	/piq/	/hoq/	/nee/,/nvl mei/	/shv lv/	/churl/
hand	breast	shoulder blade	rib	heart	to think	lung
						
/guaq/	/hol/	/zil/	/bbv/	/geeq/	/sel/	/bbiu liu/
diaphragm	stomach	pancreas	intestine	gut	liver	kidney
						
/teel/ lumbar spine	/shai/ blood	/mgv/ tendon	/shee/ meat	/cel/ misfortune	/ua/ bone	/lai/ penis
/pv/ male	/mei/ female	/kee/ foot				

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