Lexico-semantic stability in the anatomical domain in the Mayan language family

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This paper deals with lexico-semantic stability, specifically in the anatomical domain. The main goal is to develop a method for measuring semantic polysemy and shift, in order to address: (1) the validity of standardized vocabulary lists (e.g., Swadesh 1950, 1952, 1955; Holman et al. 2008; Haspelmath & Tadmor 2009a, 2009b) for investigating cross-linguistic stability; and (2) the difference between basic and stable vocabulary (Ratliff 2006; Matisoff 2009), and its implications for studying remote relationships between language families, on the one hand, and subgroup differentiation within language families, on the other. To study these problems, a total of 50 etyma from the anatomical domain were selected from the Preliminary Etymological Mayan Database (Kaufman with Justeson 2003), and these were then classified employing the novel metric, and further analyzed by means of statistical methods. The results point to: (1) no specific correlation with the stability rankings of the Swadesh and Leipzig-Jakarta lists; (2) support for the "basicness" of etyma from the anatomical domain; (3) several significant relationships between stability and polysemy scores and independent variables relevant to the anatomical domain; (4) evidence of lexico-semantic stability score affinities between Mayan subgroups; and (5) evidence supporting the utility of polysemies to investigate subgrouping and language contact. The paper also offers conclusions and areas for further research.

Keywords: semantic change, anatomical domain, Mayan languages, polysemy

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1. Introduction

This paper approaches the topic of historical and variationist semantics by focusing on the anatomical domain. There are several good reasons for studying this domain. First, its structural, variationist, and diachronic traits, including possible tendencies of change, have been the subject of detailed investigation for several decades (e.g., Stark 1969; Brown 1976; Stross 1976; Andersen 1978; Matisoff 1978; Wilkins 1981, 1996; Witkowski & Brown 1985; Snoek 2013, 2015; Pattillo 2014, 2018; Urban 2018). Second, the anatomical domain is of universal relevance, being a constant among humans past and present (Stross 1976: 243–244; Andersen 1978: 246; Matisoff 1978: 149–151; Snoek 2015: 236), a major factor in its dominant presence in word lists used for historical linguistic investigations (Swadesh 1950, 1951, 1952, 1954, 1955, 1956; Lees 1953; Holman et al. 2008; Haspelmath & Tadmor 2009a, 2009b; Tadmor 2009; Tadmor, Haspelmath & Bradley 2010). Finally, because of this last point, the anatomical domain could be of great utility in exploring the distinction between basic and stable vocabulary (Ratliff 2006; Matisoff 2009), an important question for comparative and historical reconstruction, with the potential to elucidate approaches to remote comparisons between language families, on the one end, and the differentiation of subgroups within language families, on the other.

Given these considerations, this paper aims to study a dataset of 50 Mayan etyma from the Preliminary Mayan Etymological Database (PMED) by Kaufman with Justeson (2003). Perhaps more interestingly, the paper introduces a novel metric for quantifying degrees of polysemy and shift, and thus, it is also a response to calls for studying lexico-semantic change by means of a more systematic and quantifiable approach (Matisoff 1978; Wilkins 1996).

The paper is organized as follows. Section 2 defines polysemy and shift, and reviews prior calls for the quantification of semantic change. This section also reviews two important word lists, the ranked Swadesh and Leipzig-Jakarta word lists, as well as proposals related to the implications of basicness, stability, and borrowability for historical linguistic research. Section 3 introduces the novel metric for assessing semantic change by quantifying polysemies and shifts, and discusses the assumptions involved in the procedure, as well as an outline of the statistical methods used. Section 4 introduces the PMED, outlines the analytical framework for historical comparison and reconstruction employed in our research, sketches the basic morphological and syntactic traits of relevance to the anatomical domain in the Mayan languages, and presents examples of how the new metric has been applied to quantify polysemies. Section 5 presents and discusses the results. Finally, Section 6 presents the conclusions and areas for further study.

2. Quantification of semantic change and semantic stability

2.1 Polysemy, shift, and semantic change

We follow Wilkins' (1996: 269) definition of semantic change, as it pertains to lexical semantics, as "not a change in meaning per se, but the addition of a meaning to the semantic system or the loss of a meaning from the semantic system while the form remains constant," with "semantic system" referring to a set of semantic features that characterize the meaning of the form, e.g., a lexeme. In such definition, "semantic changes within a speech community involve polysemy at their beginning point or at their endpoint" (1996: 269). Polysemy, a condition wherein a lexeme bears two or more *related* meanings, often develops through semantic processes such as metaphor and metonymy, as well as narrowing (i.e., restriction, specialization) and broadening (i.e., expansion, generalization); in such cases, the meanings are related to each other, and one can be said to be primary, the other(s) secondary or derived.[1] Lexico-semantic shift, or "absolute lexical change" (Brown 1979: 266), is defined as a situation whereby the primary meaning of a polysemous lexeme has been lost, and only subsequent, related meanings remain. We define the specific processes of semantic change of relevance to this paper in Section 3.1.

2.2 Need for a quantitative approach

A principled approach to semantic change, particularly to semantic polysemy and shift in the anatomical domain, is needed in order to study tendencies of polysemy and shift and apply the results to other historical linguistic problems (e.g., remote relationships, internal subgrouping). In his work on variational semantics in Tibeto-Burman, Matisoff (1978: 104–105) proposed a metric for gauging semantic distance between cognates; he illustrated it using English and German cognates, as seen in Table 1. Matisoff (1978: 105) would also assign low scores to "etyma which only survive in a compound or set expression rather than in isolated root form," as well as cognates "which hang on only in archaic or poetic language, but which are not known to the average speaker" or "which are dialectal

1. Wilkins (1996: 270) argues that polysemy may arise from processes other than semantic extension processes, such as reduction (ellipsis) of collocations (e.g., compounds, adnominal possession constructions), as with the case of *commercial* 'concerned with or engaged in commerce; a television or radio advertisement', where the second meaning was the result of ellipsis of *commercial message* or *commercial advertisement* into *commercial*. Nevertheless, Brown (1979: 265) would consider this to be a process akin to metonymy or synecdoche, wherein the part represents the whole, and Witkowski and Brown (1985) had previously investigated such process, referring to it as secondary polysemy.

rather than standard," adding, after these remarks, "Granted, this gets very complicated." Indeed, he further laments that this approach "is subjective," alluding to the lack of "principled ways of measuring degrees of semantic divergence." We conclude that this metric is indeed too subjective and complicated to be easily applied within a language family, much less across language families.[2]

Table 1. Matisoff's (1978: 104–105) Illustrated Metric and Scoring System

Item #	English	German	Score
1	Louse	Laus 'louse'	10
2	Sheath	Scheide 'sheath'	10
3	Flesh	Fleisch 'meat'	9
4	Bone	Bein 'leg'	7
5	Dish	Tisch 'table'	7
6	Beam (of wood)	Baum 'tree'	4
7	Nimble	Nehmen 'to take'	2
8	Tree	–	0

In his discussion of tendencies of change in the anatomical domains across several language families, Wilkins (1996: 297) hints at a possible mechanism for scoring "semantic distance." However, one key aspect of his suggested method seems difficult to implement: it is not immediately clear whether there is a single way of counting how many "natural semantic shifts" are needed to bridge any two notions, and thus the problem of subjectivity arises once again:

> For instance, phonologically similar forms for 'lip' and 'bone marrow' might receive a semantic distance score of 6 because it would normally take 6 natural semantic shifts to bridge these notions: 'lip' → 'mouth' → 'face' → 'head' → 'skull' → 'brain' → 'bone marrow'. The distance here might be weighted even more heavily due to the fact that the strictly unidirectional changes of 'mouth' → 'face' → 'head' mean that 'lip' and 'bone marrow' are not equally plausible starting points for the association; 'lip' had to be the starting point. So, while 'lip' and 'bone marrow' are semantically very divergent, they are not so divergent that phonologically similar forms for these two notions can be summarily dismissed as unrelated.
>
> (Wilkins 1996: 297)

2. It is the kind of metric that someone who is very well-versed in the languages and the history of the languages would be able to achieve. But even so, it is entirely possible that no two scholars with the same training in the relevant languages would arrive at the same rankings using Matisoff's approach. And applying such metric to a few dozen etyma would not necessarily be a straightforward process, nor one that would be entirely reproducible.

This approach was envisioned by Brown (1979), who has argued that lexical change is largely "conjunctive," implying a progression of the type X > Y > Z, and "transitive," wherein progressions exhibit transitional states, X > X,Y > Y. However, even if both Brown (1979) and Wilkins (1996) were correct that such progressions and transitions are unilinear, it seems likely that there is more variability in the number and types of steps that could be documented cross-linguistically, which would make any attempt to quantify all the possible steps too unwieldy.

In Section 3 we propose a novel metric for quantifying polysemies and shift, one that can be easily applied assuming a starting point – the reconstruction of a proto-gloss (which may or may not exhibit polysemy) for a given lexeme. This metric will allow for the comparison of the relative stability of etyma within a language family, and also, to assess the cross-linguistic validity of standardized, basic vocabulary lists.

2.3 Standardized word lists

As already observed, the anatomical domain figures prominently in the standardized word lists proposed to consist of both basic and stable vocabulary, vocabulary that is (presumably) less prone to borrowing, employed by historical linguists and field linguists alike. Such lists include the Swadesh 100-basic vocabulary list (Swadesh 1950, 1952, 1955; Lees 1953), the ASJP 40-word list based on the most stable items from the Swadesh list (Holman et al. 2008), the Leipzig-Jakarta list (Haspelmath & Tadmor 2009a, 2009b; Tadmor 2009; Tadmor, Haspelmath & Taylor 2010), among others. In fact, 26% of the Swadesh 100-word list, 25% of the Leipzig-Jakarta 100-word list, and 30% of the ASJP 40-word list consist of anatomical vocabulary. No other lexico-semantic domain makes up such a large proportion in any of these lists, justifying the need to further investigate the anatomical domain, and to further test the validity of such standardized lists.

The Swadesh and Leipzig-Jakarta lists exhibit a 62% overlap (Tadmor 2009: 73). The former was the result of a largely intuitive approach to cross-linguistic comparison by a single author, while the latter was the result of a survey approach to borrowability and other factors (representativeness, analyzability, age) by specialists of 41 languages as part of the Loanword Typology project (Haspelmath & Tadmor 2009a), whose results are archived in the World Loanword Database (WLD) (Haspelmath & Tadmor 2009b).[3] The 41-language sample is not entirely representative, as the authors of the project admit, in large part due to practicality: it is based on the languages that authors were willing to invest time preparing datasets for, and in many cases interest in the project was stim-

3. The WLD is available online at https://wold.clld.org.

ulated by knowledge that a certain language in fact exhibited many loanwords. In a sense, such bias is useful, because it allows specialists to study borrowability more intensely. Among the results of the study, Tadmor, Haspelmath and Taylor (2010) highlight the following findings, some of which are not surprising, but all of which are now more easily quantifiable: nouns (31.2%) are more borrowable than adjectives (15.2%) and verbs (14.0%); and content words (25.2%) are more borrowable than function words (12.1%). More interestingly, for our purposes, of the 22 semantic fields investigated (2010: 232–233), "The Body" was 20th in borrowability, with only 14.2% of the total number of items in the field consisting of loans, a remarkable finding given that this field contain the largest number of items, 159, of any of the semantic fields: in fact, the total number of items across all 22 fields is 1,391, with the mean of 63.23, the median of 54, and the modal of 75. Across semantic fields, loanwords exhibit a mean of 24.88%, a median of 24%, a maximum of 41.2% (Religion and Belief), and a minimum of 11% (Sense Perception). Tadmor, Haspelmath and Taylor (2010: 232) conclude that their findings "confirm the old view that words with culture-free meanings are less likely to be borrowed." The authors qualify such statement elsewhere as "relatively culture-free meanings," and include among such meanings the following fields: "sense perception, spatial relations, and body parts." Tadmor (2009: 71–72) had previously offered similar remarks.

We carried out a test of this proposed generalization with DATAtab (DATAtab Team 2022). Using the dataset in Tadmor, Haspelmath and Taylor (2010: 232–233, Table 3), reproduced in Appendix 1 (Table 1), we categorized "the body," "spatial relations," and "sense perception" as (relatively) "culture-free", and the remaining 19 as "culture". The descriptive statistics are provided in Table 2a, showing that the fields categorized as "culture" showed higher values for loanwords than those categorized as "culture-free." The distribution is illustrated graphically in Figure 1a. We then carried out a t-Test for Independent Samples. The results ($t(20) = 3.16$, $p = 0.005$, 95% confidence interval [4.65, 22.7]) showed that the difference between "culture" and "culture-free" with respect to the dependent variable "loanwords" was statistically significant. If certain additional semantic fields (Animals, Cognition, Physical World, Motion) are also categorized as (relatively) "culture-free"; their distribution with respect to the percentage of loanwords in the WLD would be described as in Table 2b and illustrated as in Figure 1b. Another t-Test for Independent Samples was carried out, and the results ($t(20) = 3.17$, $p = 0.005$, 95% confidence interval [3.44, 16.73]) once again indicate that the difference is statistically significant.

One last point is worth making about the Leipzig-Jakarta word list. It takes into account multiple factors (Tadmor 2009: 68–72; Tadmor, Haspelmath & Taylor 2010: 239–241): borrowability, representation, analyzability, and age. Items

Table 2. Descriptive Statistics for Percentage of Loanwords Across "Culture" vs. "Culture Free" Semantic Fields in the World Loanword Database

a. 3 "culture-free" semantic domains

		N	Mean	Std. deviation	Std. error mean
Loanwords	Culture	19	26.74	7.31	1.68
	Culture-free	3	13.07	1.79	1.03

b. 7 "culture-free" semantic domains

		N	Mean	Std. deviation	Std. error mean
Loanwords	Culture	15	28.09	7.51	1.94
	Culture-free	7	18	5.44	2.06

on the list received scores for each of these criteria, and a composite score that was employed for the overall ranking that constitutes "a full-fledged basic vocabulary ranking" (Tadmor 2009: 68). Given this, we thought it would be interesting to check again what the status of the anatomical domain would be in the final 100-word Leipzig-Jakarta list. As expected, when the 100 items on the list (Tadmor, Haspelmath & Taylor 2010: 239–241, Table 7), provided here in Appendix 1 (Table 2), were divided according to their semantic fields (2010: 243, Table 9), the anatomical domain shows the lowest mean rank value of all the semantic fields, indicating that such domain is more resistant to borrowing, as seen in Table 3 and Figure 2. Furthermore, a Kruskal-Wallis Test of Independence was carried out with DATAtab (DATAtab Team 2022) to check for statistically significant differences between the semantic fields (nominal variables) with respect to the ranks (ordinal variable) assigned to the items in the list. The results ($X^2(6) = 13.18$, $p = 0.04$) support a statistically significant difference among the semantic fields with respect to rank. This supports the proposition that overall, the anatomical domain is the most conservative.

The Leipzig-Jakarta word list constitutes a significant advance over the Swadesh list. Given the importance of the approach by Holman et al. (2008), their ranked version of the Swadesh list was considered as well. In this paper, we address the issue of lexico-semantic and semantic stability within the anatomical domain in the Mayan language family, and we compare our results with those from the Leipzig-Jakarta list and the ranked Swadesh list, in order to assess to what extent they are consistent with the cross-linguistic rankings.

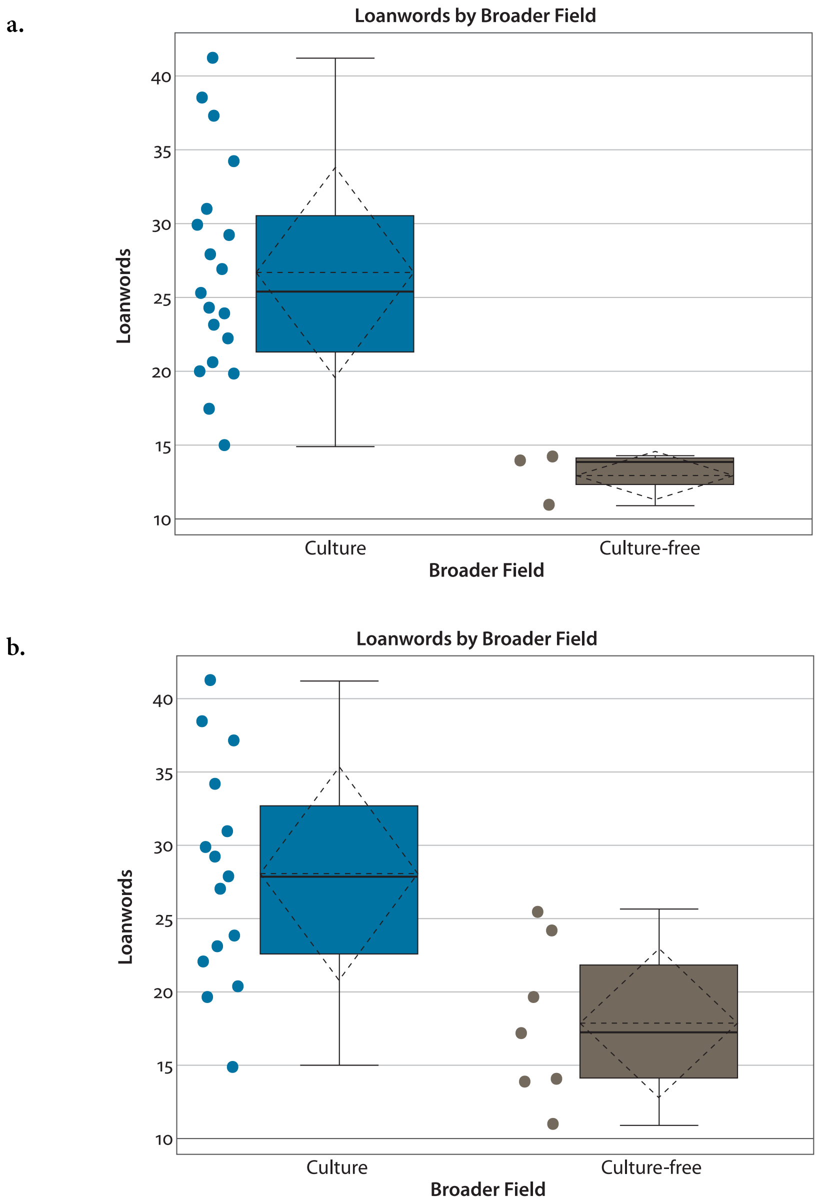


Figure 1. Box plots of distribution of loanwords (percentage) across "Culture" and "Culture Free" semantic fields, prepared with DATAtab: (a) Box plot taking into account 3 "culture free" semantic fields, (b) Box plot taking into account 7 "culture free" semantic fields

2.4 Basicness and stability

Ratliff (2006: 1) set up a basic distinction between ±basic vocabulary, referring to "words that speakers of all languages need to have," and ±stable vocabulary, refer-

Table 3. Rank Means by Semantic Field

Groups	**N**	**Mean rank**
Anatomy	27	37.37
Grammatical	10	40.9
Cultural	3	44.83
Natural phenomena	13	50.27
Animal	7	53.71
Actions	25	59.48
Properties	15	65.4
Total	**100**	

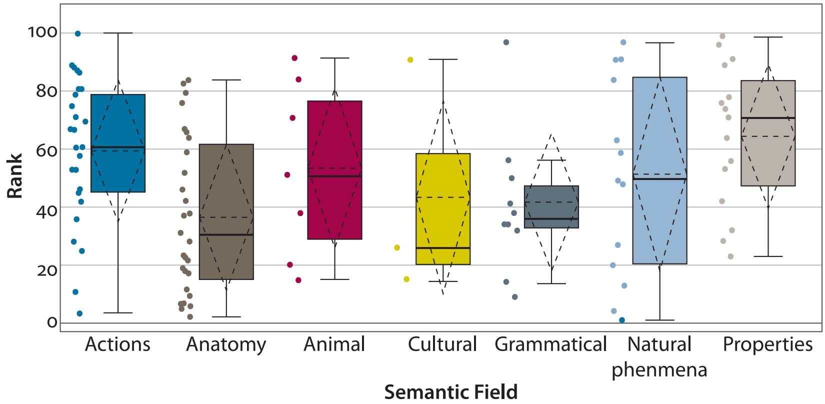


Figure 2. Semantic Fields in the Leipzig-Jakarta Word List According to Rank, Prepared Using DATAtab (DATAtab Team 2022) with Dataset from Tadmor, Haspelmath and Taylor (2010: 239–241, Table 7)

ring to "words that all languages in a particular family share."[4] This definition sets up a four-way classification of vocabulary, which Ratliff illustrates with Hmong-Mien vocabulary: [−basic, −stable] (e.g., butterfly, joke, or, thumb); [−basic, +stable] (e.g., silver, 100, liquor, taro); [+basic, −stable] (e.g., mountain, head, give, not); and [+basic, +stable] (e.g., flower, die, hair, fire).

4. Matisoff (2009: 292) notes that the "all languages in a particular family share" requirement is too ambitious, especially when one is dealing with larger language families. He introduces the concept of a *stability continuum*.

Both Ratliff (2006) and Matisoff (2009) have argued for the significance of [+basic, +stable] and [+basic, −stable] vocabulary for historical and comparative research. The former, [+basic, +stable] vocabulary, would be crucial for identifying remote linguistic relationships; the latter, [+basic, −stable] vocabulary, "is especially useful for establishing isoglosses among subgroups of a language family" (Matisoff 2009: 292).

In this paper, we will attempt a classification of [±basic, ±stable] anatomical vocabulary for the Mayan language family by means of the novel metric described Section 3. We will use this classification to isolate the [+basic, +stable] examples as potentially useful for remote comparisons (e.g., between Mayan and Mixe-Zoquean), as well as the [+basic, −stable] vocabulary to test its correspondence with established Mayan subgroups.

3. A novel metric for polysemy and shift

3.1 Assumptions

We assume that it is possible to apply a kind of comparative method to reconstruct the meanings of proto-lexemes. This comparative method is not the same as the Comparative Method. The procedure, which should be reproducible and applicable to other language families, especially if such families exhibit significant branching, is further described and illustrated in Section 4.3.

As for types of polysemies and shifts, we have employed the classification in Table 4, a synthesis based on the work of several authors over the past few decades (Stark 1969; Stross 1976; Matisoff 1978; Wilkins 1996). In addition, we have also classified cases of specialization (or narrowing), defined on the basis of the reduction of polysemy: if a proto-gloss was reconstructed as exhibiting polysemy, as with the case of proto-Mayan *nhii7 ~ *nhuu7 'nose; point/tip; beak', and a descendant language attests to only two or only one of the reconstructed senses, then we classified the process at work in such language as specialization or narrowing. We also classified cases of generalization (or broadening), as illustrated in the case of proto-Mayan *7aaty 'penis', which is attested as polysemous 'penis; genitals' or shifted 'genitals' in some languages, and thus constituting a case of extension of a term for male genitalia to both male and female genitalia. It is possible that some cases of specialization and generalization could also be cases of metonymy or metaphor, but in some cases, it is not immediately obvious how such extension would have proceeded precisely. What matters, in this paper, is simply that a process can be cited as a cause of the observed polysemy or shift.

Table 4. Synthesis of Classifications of Polysemy Processes in the Anatomical Domain

		Metaphor (similarity)	**Metonymy (contiguity, association)**	**Synecdoche (part-whole)**
Interfield	Ingressive	leaf > ear cave > belly	to walk > legs earring > ear	
	Egressive	head > top (of mountain)	eyes > contact lenses/glasses (English) to foot it (distance) > to walk/cover a major distance (English)	
Intrafield		elbow > knee (knee > elbow)	chest > belly (belly > chest)	finger > hand

3.2 Proposed metric

The metric we propose differs from those proposed by Matisoff (1978) and Wilkins (1996). While we do attempt to gauge semantic distance between cognates, as Matisoff proposed, our approach is not meant to be fine-tuned. We attempt to establish both the presence of polysemies and shifts, but we are not attempting to gauge how many "steps" it takes for one sense to arise out of another. Our metric is much more limited, but we believe, objective.[5] Starting from a proto-meaning or proto-gloss, it counts whether such proto-meaning: (1) has been retained exclusively, resulting in a ranking of 3 for 'very stable'; (2) developed polysemies (regardless of how many) while retaining the original meaning, resulting in a ranking of 2 for 'stable'; (3) has undergone full shift (regardless of how many derivative meanings), with the original meaning lost, resulting in a ranking of 1 for 'unstable'; or (4) has become lost completely, or replaced by a different etymon with an equivalent meaning (or set of meanings), resulting in a ranking of 0, for 'very unstable'. Table 5 explains the metric.

5. The number of meanings per etymon in the dataset employed in this paper ranges from 1 to 10 (Mean 3.98, Standard Deviation ± 2.76).

Table 5. Proposed metric for application in this paper [Note for typesetters: Score a column should have thick vertical lines]

Language A	Score A	Explanation
*LEXEME$_1$ 'x' > 'x'	3	Descendant language retains proto-gloss 'x'
*LEXEME$_1$ 'x' > 'x; y; …'	2	Descendant language exhibits polysemy (no matter how many different senses 'x', 'y', 'z', etc.), but retains the proto-gloss 'x' as one of the two or more senses
*LEXEME$_1$ 'x' > 'y' (LEXEME$_2$ 'x')	1	Descendant language has experienced shift (proto-gloss 'x' is not retained); some other LEXEME$_2$ (whatever its source) may bear meaning 'x'
*LEXEME$_1$ > Ø (LEXEME$_2$ 'x')	0	*LEXEME$_1$, has been lost/replaced completely; only alternative LEXEME$_2$ (whatever its source) exhibits equivalent meaning

3.3 Lexico-semantic stability measure (Stability 1/2/3)

This is the most important metric for the purposes of this paper. It is defined on the basis of two parameters: retention of the etymon, and semantic change experienced by such etymon determined by polysemy and shift. This metric considers whether the etymon has been lost in a subgroup (or more than one). This is a useful metric for assessing the utility of standardized word lists. Stability 1 is the score for individual languages; Stability 2 is the score for subgroups; and Stability 3 is the score for an etymon across all languages.

3.4 Semantic stability measure (Stability 4)

It may also be useful to assess the overall semantic stability of an etymon regardless of its lexical stability: that is, among the languages that have retained the etymon in question, how stable have the meanings of such etymon been? This measure, Stability 4, requires eliminating the subgroups from which the etymon has been lost, and counting only those subgroups in which at least one language has retained it.

3.5 Statistical tests

Using the Stability 1/2/3 and Stability 4 measures as a basis for comparison, the paper will also carry out statistical tests to investigate possible influences of linguistic and non-linguistic variables on semantic polysemy and shift, as well as differences among subgroups. Table 6 outlines the variables, both dependent and independent, to be studied.

Table 6. Variables considered in this study: See Appendix 6 comprehensive dataset

Variables	Header title	Type	Values
Dependent	Stability 3	Metric	0–3
	Stability 3	Ordinal	Low 0–1.5, High > 1.5–3
	S3 Rankings		1–40
	Stability 4	Metric	0–3
	Stability 4	Ordinal	Low 0–1.5, High > 1.5–3
	S4 Rankings		1–46
	Polysemy	Metric	1–10
Independent	Stage	Ordinal	pM, LpM, pCM
	Part or Function	Nominal	Part, Function (Function = Product or Function)
	Area of Body	Nominal	Face, Head, Limb, Mouth, Nose, Pelvis, Rear, Torso, Whole Body
	Basicness	Ordinal	Yes, No (inclusion in standardized word lists)
	Expected	Nominal	Odd, Expected (agreement with family tree)
Non-variables	ID		Record identification
	Etyma		Etymon
	Gloss		Earliest reconstructed gloss

The datasets have been prepared with Apple Numbers but have been exported as CSV files and added as Appendix 1 and Appendices 5–10 to this paper; **Appendices 4–11** are only available online. The statistical tests, which include hypothesis and correlation tests (e.g., parametric and non-parametric, including Analysis of Variance, Hierarchical Cluster Analysis, T-tests for Independent Samples, Friedman Test, Kruskal-Wallis Test, Spearman Correlation, Mann-Whitney U-Test) have been carried out mostly with DATAtab (DATAtab Team 2022), but the HCA have been conducted with StatPlus for Mac. Parametric tests were carried out whenever the data exhibit a normal distribution, and non-parametric tests when they do not.

4. Mayan dataset

4.1 Mayan differentiation and diffusion zones

The Mayan language family was historically spread across Southeastern Mexico, Guatemala, and parts of Belize, Honduras, and El Salvador. Figure 3 illustrates Kaufman's (2017) diversification model. The 32 Mayan languages can be traced back to a common ancestor, proto-Mayan (pM).[6] Following Kaufman's (1976, 2017) diversification model, pM split into Wastekan (Wa) and Late proto-Mayan (LpM) (aka Southern Mayan or Core Mayan); LpM differentiated into Yukatekan (Yu) and Central Mayan (CM); CM split into Eastern Mayan (EM) and Western Mayan (WM); EM further differentiated into Greater Mamean (GM) and Greater K'ichee7an (GK'); and WM further differentiated into Greater Tzeltalan (GT) and Greater Q'anjob'alan (GQ'). The language abbreviations employed by Kaufman (2017) will be used throughout the paper. Below (Section 5.3), we offer evidence that lessens the need for such a restrictive, early binary differentiation of pM into Wa and LpM, at least on the basis of lexico-semantic data.

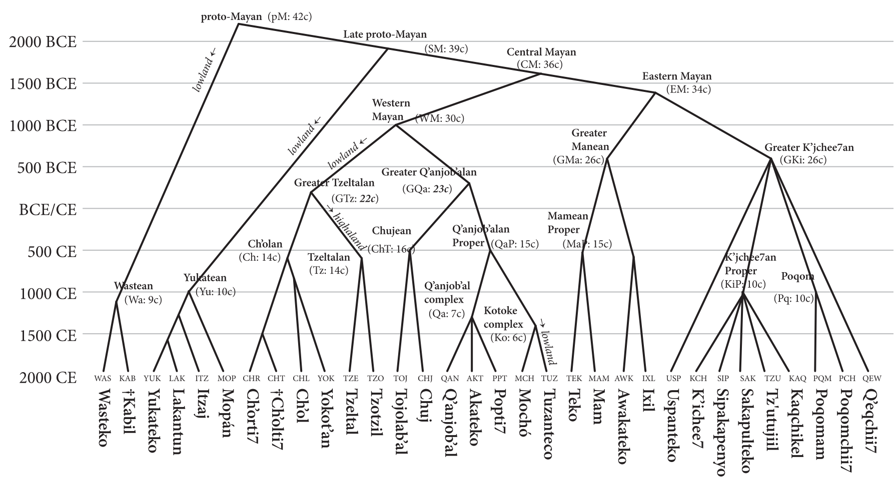


Figure 3. Diversification of the Mayan Languages (Kaufman 2017)

It is also important to note that there exist several contact zones within the Mayan region (Justeson et al. 1985; Kaufman 2015, 2017; Law 2017): Greater Lowland Mayan (GLL) (Ch'olan, Tzeltalan, Yucatecan; also some contact with GQ'

6. We have replaced Kaufman's *Southern Mayan* with a label previously used by Kaufman himself (cf. Kaufman with Justeson 2003), Late proto-Mayan (i.e., proto-Mayan minus Huastecan).

and GK' languages); Lowland Mayan (LL) (Ch'olan, Yucatecan; also some contact with GQ' and GK' languages, especially, among the latter, Q'eqchi'); the Chiapas Sphere (Tzeltalan, Western Ch'olan); and the Huehuetenango Sphere (Q'anjob'alan Proper, Mamean Proper). These diffusion zones or contact spheres will be of importance for evaluating patterns of distribution of etyma and their meanings. In fact, two of these diffusion zones, GLL and LL, encompass the area of attestation of Epigraphic Mayan, which spans the Late Preclassic (400 BCE–CE 200), Classic (CE 200–900), and Postclassic (CE 900–1521) periods. While Epigraphic Mayan was likely innovated by Ch'olan speakers, it is known to have represented several Ch'olan and Yucatecan varieties by the end of the Classic period (cf. Mora-Marín 2009).

We can justify focusing on the Mayan language family because of the following four criteria: (1) the advanced stage of its phonological reconstruction (cf. Campbell 2017), which provides anchor points for inferences about diachronic developments and diffusion of etyma; (2) the availability of the PMED (cf. Section 4.2); (3) the detailed attention paid to the anatomical domain in individual Mayan languages by a variety of authors (e.g., Brown 1971, 1976; Stross 1976; Campbell et al. 1986: 545–546; de León 1992; Hofling with Tesucún 1997); and (4) the decipherment of Epigraphic Mayan, which can offer absolute and relative temporal anchor points for specific meanings of many of the relevant etyma.[7]

4.2 PMED

We have utilized Kaufman with Justeson's (2003) *Preliminary Mayan Etymological Dictionary*, henceforth PMED, containing over 3,000 etymologies and 46 semantic domains, including almost 150 pages of anatomical etyma (body parts, bodily effluvia, bodily processes). We decided to study a total of 50 anatomical terms reconstructible to pM, LpM, or pCM. These are listed in Appendix 2, sorted alphabetically in Mayan, and Appendix 3, sorted alphabetically in English. The PMED is divided according to semantic domains. Anatomical etyma are included within two domains: "Body parts and other parts; bodily processes," and "Animal parts." Within each domain, there are *subdomains* that are typically labeled with capital letters (e.g., TOOTH), and each such subdomain may include a number of *lexeme units* based on different roots (e.g., WM+LL *cha7am, pM *7eeh, pM *kooh, etc.), and each lexeme unit may include a number of lexemes or constructions based on the same root reconstructed to the same stage or subgroup (e.g.,

7. The term "Epigraphic Mayan" was coined by Kaufman (cf. Kaufman with Justeson 2003). It now serves as the basis for the ISO code (ISO 639-3 emy).

pM *7eeh, pM *r-eeh pM *u-Haty ERG-eeh) or reconstructed to different stages or subgroups (e.g., pM *kooh, GLL *kooh 7iit).[8]

A typical entry in the PMED provides a reconstructed etymon and beside it, a proto-gloss. Other entries do not provide a specific proto-gloss, but the likely reconstruction is obvious, as with pM *palanh 'forehead', contained within the subdomain labeled FACE, but for which every cognate bears such the gloss 'forehead'. Alternatively, the specific entry may lack a proto-gloss, but the subdomain heading points to Kaufman with Justeson's (2003) estimation of the likely proto-gloss; this is the case of pM *kik', which appears immediately under the subdomain heading BLOOD. Some entries appear within a section with no subdomain heading, but their likely proto-gloss is obvious from the glosses provided for a majority of reflexes, as with the case of pM *b'aaq, attested in every branch of the family, with most languages, and all subgroups, attesting to the gloss 'bone', sometimes exclusively (2003: 357–359).[9]

Of the 50 etyma studied here, 19 (38%) were given specific proto-glosses by Kaufman with Justeson, and 31 (62%) were included within a glossed section but not given a specific proto-gloss. Out of the former subset, we have revised 2 of the proto-glosses by Kaufman with Justeson (items #16 and #31). For the latter subset, we have proposed proto-glosses that generally agreed with the subdomain headings, in some cases based on an overwhelming agreement among the cognates (e.g., pM *kik' 'blood'), but in others based on a more careful consideration of the distribution of glosses across the subgroups. In some such cases the proto-gloss proposed for an etymon is a revised version of that provided by Kaufman with Justeson, as with the case of pM *wi7, included within a subdomain HAIR, but for which we proposed the proto-gloss 'head; hair' based on the distribution of glosses among the individual languages and the subgroups within the family. We have provided justifications for each of our proto-glosses in Appendix 4, not-

8. Kaufman with Justeson (2003) utilizes the following practical orthography IPA correspondences: <7> for <ʔ>, <b'> for <ɓ>, <tz> for <t͜s>, <ch> for <t͜ʃ>, <x> for <ʃ>, <j> for <x>, <nh> for <ŋ>, <w> for <ʋ>, <y> for <j>, and <VV> for <Vː>. A few Mayan languages bear a sixth (short) vowel, usually [ə] or [ɨ], represented in this paper as <ä>. We have regularized data cited from various sources according to these conventions. The orthography for data from non-Mayan languages is transcribed as in the original source.

9. Kaufman (2017: 74–75, 77–78) has recently published a Swadesh list of reconstructed Mayan etyma, including most of the relevant anatomical terms, and has also presented detailed discussions of reconstructed lexical domains, but unfortunately did not include a section on anatomical terms. His recent reconstructions are consistent with those in the PMED, except he appears to have revised the historical stage for a couple of them. We have decided to restrict ourselves to the more comprehensive and varied data from the PMED.

ing, whenever it is relevant, cases where we have revised the glosses present in the PMED for individual languages based on evidence from detailed dictionaries.

4.3 Basis for reconstruction and sources of error

We apply a comparative reconstruction methodology, but one that is only loosely related to the Comparative Method. When applied to the study of sound change and phonological reconstruction, the Comparative Method aims to detect regular sound correspondences; should these be present and pervasive across the vocabulary, phonological reconstruction can proceed, taking into account attested directionalities and tendencies of sound change, as well as crosslinguistic patterns of sound systems. We do not claim to have invented a means of detecting regular semantic correspondences, analogous to sound correspondences, much less implemented such a method to attempt semantic reconstruction.

Matisoff (1978: 173–174) offers three options for carrying out the task of assessing the proto-gloss of an etymon that is phonologically cognate between any two languages ("inter-lingual" situation), or in some cases, assessing the directionality of change between different glosses of the same etymon in a single language ("intra-lingual" situation): (a) reconstruct only on the basis of exact correspondence between glosses; (b) reconstruct a situation of polysemy ("semantic vagueness") in the proto-language; or (c) reconstruct a proto-gloss and explain how that gloss has changed in subsequent stages. He notes that the distinction between (b) and (c) "is very tenuous." He illustrates the case of Modern French *tête* 'head', from Late Latin *testa* 'pot', and suggests that it is very likely that an earlier form of Gallo-Romance may have shown a form *teste* with glosses 'a pot, as for cooking' and '(slang, vulgar) the head', followed at a somewhat later stage by 'the head' and '(archaic) a pot'. In this paper, we follow all three of these options. Some proto-glosses are obvious: all cognates show an identical gloss (e.g., proto-Mayan *hat'is 'sneeze', Appendix 3, item #3). Others imply variation and change (e.g., proto-Mayan *baaq 'bone', Late proto-Mayan *b'aaq 'bone; skinny', etc., Appendix 3, item #1, discussed below). This is when our approach implements an additional procedure not explicitly raised by Matisoff: we utilize the distribution of variable glosses across the subgroups as a guide to reconstruct a proto-gloss.

More specifically, the comparative reconstruction methodology applied here relies on the distribution of PMED *glosses* for lexical cognates across the tree structure of the Mayan family (cf. Figure 3): (1) we weigh the glosses that are more widely distributed across the tree structure (e.g., present in a majority of subgroups) more heavily than those that are more narrowly distributed (e.g., present in just one subgroup); (2) we weigh glosses less heavily when they are shared by subgroups known to have experienced intense (lexical, phonological, morphological, syntactic) diffusion – recall the diffusion zones introduced in Section 4.1; (3) we categorize the semantic extension processes that resulted in polysemies and shifts, though this step is only relevant for a planned future paper; and (4) we propose a proto-gloss that takes these factors into account.

Table 7 provides an example of the datasets and steps in the procedure; it is an excerpt from the dataset in Appendix 5. The gloss 'bone' (cf. Appendix 3, item #1) applies to 30 of the 32 languages, and it is attested in every subgroup. It is clear that we can propose *'bone' as a proto-gloss. The next most frequent meaning, 'skinny', likely a case of interfield metaphorical extension (referring to a quality of a person, not a part of the body), is attested 12 times, and is absent from two subgroups (Wastekan, Greater Mamean), thought their overall distribution supports a LpM reconstruction. Hence, we can reconstruct LpM *b'aaq with the proto-gloss *'bone; skinny'. The next most frequent meanings, 'needle', likely a case of interfield metonymic extension (since needles were made of bone), and 'skull', likely a case of secondary polysemy (Witkowski & Brown 1985: 204–205) through elision of the possessor noun in the phrase 'the bone of the head/dead/face' (cf. Appendix 3, item #1), are each attested 9 times, only among languages from the four subgroups comprising the CM grouping. However, their distribution requires a more careful weighing: 'needle' appears in only one WM language, Q'anjob'al, a language that has been influenced by the GM languages in the context of the Huehuetenango Sphere, and thus, 'needle' can be more safely attributed to EM; similarly, 'skull', though attested in CM languages, is restricted to only two WM languages, and once again, it is safer to propose this gloss to an EM stage, rather than an earlier CM stage. Thus, it is possible to reconstruct pCM *b'aaq with the proto-gloss *'bone; skinny', and pEM *b'aaq with the proto-gloss *'bone; skinny; needle; skull'.

This approach relies on the accuracy of glosses in the PMED, which is based on fieldwork notes by Kaufman, as well as a myriad other sources, most of them dictionaries or databases compiled to prepare dictionaries, and many of them the product of native-speaker linguists. We have attempted to check all the PMED glosses against additional dictionaries, and in a few cases, we have found discrepancies: for Itzaj, Kaufman with Justeson provide the gloss 'eyebrow', but Hofling with Tesucún (1997: 432) provide 'eyelash', which we have favored as more reliable.

Any research involving dictionaries requires qualification. More specifically, there are two important sources of error that require comment. First, most dictionaries of Mayan languages are characterized by *underdocumentation* of polysemies, which could result in a bias toward the overestimation of stability. In other words, each language may very well exhibit polysemy for a given etymon, but the dictionary simply does not capture it. Only more detailed, systematic documentation of polysemies would allow for a correction of such bias. Such documentation

Table 7. Matrix Showing Meanings for Proto-Mayan *b'aaq Across Family (cf. Appendix 5)

I	II	III	IV	V	Language	Bone	Skinny	Needle	Skull	Body	Button	Totals
pM				Wa	WAS	1	0	0	0	0	0	**1**
					KAB	0	0	0	0	0	0	**0**
	LpM			Yu	YUK	1	1	0	0	0	0	**2**
					ITZ	1	0	0	0	0	0	**1**
					LAK	1	1	0	0	0	0	**2**
					MOP	1	0	0	0	0	0	**1**
		CM	WM	GTz	CHL	1	0	0	0	0	0	**1**
					YOK	1	1	0	0	0	0	**2**
					CHT	1	0	0	0	0	0	**1**
					CHR	1	0	0	1	0	0	**2**
					TZE	1	1	0	0	0	0	**2**
					TZO	1	1	0	0	0	0	**2**
				GQ'	TOJ	1	0	0	0	0	0	**1**
					CHJ	1	1	0	0	0	0	**2**
					AKA	1	1	0	1	0	0	**3**
					POP	1	1	0	0	0	0	**2**
					QAN	1	0	1	0	0	0	**2**
					MCH	0	0	0	0	0	0	**0**
					TUZ	1	0	0	0	0	0	**1**
			EM	GM	TEK	1	0	0	1	0	0	**2**
					MAM	1	0	1	1	0	0	**3**
					AWA	1	0	1	1	0	1	**4**
					IXL	1	0	1	1	0	0	**3**
				GK'	SIP	1	0	1	0	0	0	**2**
					SAK	1	0	1	1	0	1	**4**
					KCH	1	0	1	1	1	0	**4**
					TZU	1	0	1	0	1	0	**3**
					KAQ	1	1	1	1	0	0	**4**
					USP	1	1	0	0	0	0	**2**
					PCH	1	1	0	0	0	0	**2**
					PQM	1	0	0	0	1	0	**2**
					QEQ	1	1	0	0	0	0	**2**
					Totals	**30**	**12**	**9**	**9**	**3**	**2**	**65**

would ideally involve dictionaries with sample sentences with an etymon/lexeme appearing in multiple contexts, as well as a detailed, corpus study that includes texts from a variety of genres. Consequently, in addition to the PMED, we have strived to employ dictionaries that provide subentries and sample phrases or sentences that illustrate different contexts of use that can illuminate the nature of polysemies (e.g., Hofling with Tesucún 1997; Keller & Luciano 1997; Bricker, Po7ot Yah & Dzul de Po7ot 1998; Dobbels 2003; Aulie & Aulie 2009; Hofling 2011, 2014; Hopkins 2012; Hull 2016; Polian 2018).

The second problem, related to the first, likely represents a greater challenge to this type of research. It pertains to the question of researcher (and linguistic) bias in the determination of basic meanings of morphemes and lexemes, and from there, of the patterns of development of polysemy and direction of shift. Brown (1976) discusses the need to establish a "reference language," such as English, in doing research on nomenclatural patterns. The choice of a reference language obviously raises the problem of ethnocentrism (cf. Constenla Umaña 1992; Matisoff 1978: 100). We obviously have used English and Spanish as reference languages, but we have also strived to employ, when possible, sample phrases to ascertain the range of glosses for a given term. For instance, Kaufman with Justeson (2003: 349) gloss pM *7ooq as 'foot', and in fact, so do Bricker, Po7ot Yah and Dzul de Po7ot (1998: 16) for the reflex *7òok* in Yucatec Maya. Nonetheless, a detailed examination of the bounty of subentries by Bricker, Po7ot Yah and Dzul de Po7ot, most of which constitute cases of overtly marked expressions (e.g., compound nouns, adnominal possession phrases), provides various examples of this etymon where the interpretation has to be 'leg', such as *náach'-7ok* 'person with short legs' and *sitil 7òok* 'skinny legged', as well as examples where the referent must be the foot, such as *pàach 7òok* 'top of foot' and *mekel-7ok* 'clubfooted'. This means that it *is* possible to conclude that there is 'foot; leg' or 'foot/leg' polysemy, though it may not be possible to distinguish between two senses of the same word (i.e., 'foot; leg') versus one sense (i.e., 'foot/leg') that blends the two senses (i.e., 'foot' vs. 'leg') that characterize the reference languages (English 'foot' vs. 'leg', Spanish 'pie' vs. 'pierna').

4.4 Morphology and syntax of anatomical terminology

Anatomical lexemes in Mayan languages may refer to permanent parts (e.g., head, torso, limbs), bodily fluids or products that are continually renewed or dispensed with (e.g., blood, skin, urine, excrement), and parts that may be shed periodically (e.g., hair, fingernails). We also include bodily functions (e.g., sneezing, vomiting, coughing, farting, belching). Typically, the relevant etyma consist of *noun roots and stems*, *compound nouns*, and *adnominal possession constructions* (phrasal expressions consisting of a possessed noun followed by the possessor noun) in which the possessed noun, at the very least, requires inflection by means of an ergative person proclitic/prefix that indexes the possessor. A fourth type of phrasal expression that may denote an anatomical concept is what Mora-Marín (2021) refers to as *diphrastic kennings*, though other authors have referred to these as couplets or coordinated compounds: syntactically, they constitute coordinated noun phrases whose respective head nouns, together, convey a third concept via metonymy (association) or metaphor (similarity).[10] Finally, the last common type is referred to as a *relational noun*, a term coined by Terrence Kaufman; it involves (typically) a possessed anatomical term that is grammaticalized in order to express a locative, temporal, or case relation between two nominal referents. Some such relational noun constructions involve a preposition, others do not. Examples (1)–(5) illustrate these five types of constructions.

(1) Possessed noun roots and stems (± explicit possessor)
Lacandon (Yukatekan)
[7]u-wich
3sg.erg-face'
'his/her face' (Hofling 2014: 382)

(2) Compound nouns
Yokot'an (Greater Tzeltalan)
b'äk=päm (based on the roots *b'ak* + *pam*)
bone=head
'skull' (Keller & Luciano 1997: 38, 41)

(3) Adnominal possession
Ch'orti' (Greater Tzeltalan) \
u-b'ak-er u-jor
3sg.erg-bone-abstr 3sg.erg-head
'his/her skull' (Hull 2016: 62)

(4) Diphrastic expressions ("couplets" or "coordinated compounds")
Tzeltal (Greater Tzeltalan)
7ok-il k'ab-al
Foot/leg-unposs hand/arm-unposs
'limbs, extremities' (Stross 1976: 248)

10. Confusingly, Stross (1976: 246) uses the term "compound" to refer to true compound nouns, adnominal possession constructions, and diphrastic kennings, although he was aware of their distinct morphological and syntactic structures. This loose usage of the term became common in studies from the 1970s, 1980s, and 1990s.

(5) Relational Nouns: (PREP +) Adnominal Possession (Grammaticalization)
Kaqchikel (Greater K'ichee7an)
chi ru-pam
PREP 3SG.ERG-belly
'inside, within (it)' (Kaufman with Justeson 2003: 310)

Diachronically, adnominal possession constructions may become lexicalized into compound nouns: the compound noun in (2) very likely originated as an adnominal possession construction like that seen in (3). A case of synchronic variation between an adnominal possession construction and a compound noun is documented in Itzaj: *u-na7 in-koj* (3SG.ERG-mother + 1SG.ERG-tooth) 'my molar (tooth)', and *na7=koj* 'molar (lit. mother=tooth)' (Hofling with Tesucún 1997: 400, 465). Similarly, there is evidence that diphrastic kennings may also become lexicalized into compound nouns, a case in point being Tzeltal *chan=b'ahlam* 'animal', based on *chan* 'snake' and *b'ahlam* 'jaguar', and thus "implying everything from snakes to jaguars," as well as Tzeltal *te7=7ak'* 'plant', based on *te7* 'tree' and *7ak'* 'vine', and similarly "implying everything from trees to vines" (Stross 1976: 248). In fact, in Tzotzil, the language most closely related to Tzeltal, *chon* is now polysemous 'snake; animal' (Hurley & Sánchez 1978: 43), suggesting that diphrastic kennings can not only become lexicalized into compounds, but furthermore, that the first term of such a compound can then absorb the meaning of the compound after elision of the second term, a part-for-the-whole process, resulting in secondary polysemy (Witkowski & Brown 1985: 204–205). Unlike adnomimal possession constructions, several of which can be reconstructed to earlier stages of the Mayan language family (pM, LpM, CM), so far no diphrastic kennings (in any semantic domain) can be reconstructed to such stages (Mora-Marín 2021).

Finally, a few words about the lexical sources and derivational morphology of the anatomical terms are needed. Most are noun roots (e.g., pM q'ab' 'hand/arm'). Several are verbal noun roots, roots that function as verbs if inflected as verbs, but as nouns otherwise (e.g., pM *ji7q' 'to choke; choking'). Some are noun stems derived from nominal or verbal roots. An example of the latter case is Tzeltal *ch'utub'(il)* 'index finger' (Stross 1976: 247), derived from *ch'ut* 'to point' by means of *-ub'* 'instrumentalizer (i.e., 'X (verb)' > 'thing/place to do X (noun))' (the final *-il* suffix is the 'unpossession/absolute' suffix of unpossessed, inalienable nouns).

Also, in Mayan languages, anatomical terms are typically or obligatorily possessed (Mora-Marín 2021), and when not possessed, some employ 'unpossession' or 'absolute' suffixes, with individual languages varying in how many such terms require such suffixes, with some requiring them of just about every term (e.g., Tzeltal), and others none (e.g., Yucatec). Some nouns roots that refer to parts of the body (human or otherwise) that are detachable and in some cases of potential use (e.g., hair, bone, skin/hide, fur, feathers, blood, meat/flesh) typically require an abstractivizing suffix of the general shape *-VVl* (e.g., *-iil*, *-aal*, *-eel*) when they are referred to as a part of a body (i.e., attached): Yucatec *in-b'àak'* (1SG.ERG-meat/flesh) 'my meat (bought at the market)' vs. *in-b'ak'-el* (1SG.ERG-meat/flesh-ABSTR) 'my flesh (of my body)'. Although some scholars have argued that such *-VVl* suffixes are markers of 'inalienability' (e.g., Blair 1964: 50; Hofling 1990: 553; Bricker, Po7ot Yah & Dzul de Po7ot 1998: 359), it is more likely that these are simply abstractivizers employed to mark the noun as "systemic" (part of a system/whole) rather than "isolated" (or detached) (Lehmann 2003; Kockelman 2007; Mora-Marín 2021), especially when one considers that most anatomical terms are inalienable, occurring in possessed form, and that some even require a marker of unpossession when not possessed.

4.5 Some disclaimers

Six sets of etyma show overlapping (or identical) semantic reconstructions, one set for 'hair' (items #24, #31, #48); another for 'arse' (#26, #46); the third for 'foot, leg' (#43, #49); the fourth for 'woman's breast' (#33, #45); the fifth for 'belly' (5, 14); and the last for 'tooth' (#8, #44). In some cases, the etyma can be reconstructed to slightly different stages: *ʃi7 'hair; hair of head' (#24) is reconstructed to pM, as is *7ism 'fuzz' (non-head hair), while *wi7 'head; hair' (#37) is reconstructed to LpM; and *7iit 'arse' (#46) is reconstructed to LpM, while *to7p 'arse' (#26) to pCM. A couple of interpretations can be offered: the proto-gloss for one member of each set is incorrectly reconstructed; or each member of each set is correctly reconstructed, in which case each set constitutes evidence for synchronic lexical variation at an early stage. A future study paying attention to synchronic lexical variation within individual languages could illuminate cases in which two different etyma with the same or overlapping meanings co-exist in a language.

4.6 Examples of the novel metric

The novel metric proposed in this paper (cf. Section 3.2, Table 5) results in four stability measurements: (1) S1, lexico-semantic stability per language; (2) S2, lexico-semantic stability per subgroup; (3) S3, lexico-semantic stability in the language family; and (4) S4, semantic stability of the etymon in languages that preserve it. Tables 8 and 9 provide two examples of its implementation, the main difference between the two being that the example in Table 8, pM *b'aaq 'bone', shows S3 and S4 scores that agree, while the example in Table 9, pM *, shows S3 and S4 scores that do not agree, since S4 requires eliminating subgroups (Yukatekan, Greater Tzeltalan) in which the etymon is not attested at all.

Table 8. Stability Measures for pM *b'aaq 'Bone'

Language	Stability 1	Subgroups	Stability 2
WAS	3	Wastekan	3.00
KAB	3		
YUK	2	Yukatekan	2.50
ITZ	3		
LAK	2		
MOP	3		
CHL	3	Greater Tzeltalan	2.33
YOK	2		
CHT	3		
CHR	2		
TZE	2		
TZO	2		
TOJ	3	Greater Q'anjob'alan	2.00
CHJ	2		
AKA	2		
POP	2		
QAN	2		
MCH	0		
TUZ	3		
TEK	2	Greater Mamean	2.00
MAM	2		
AWA	2		
IXL	2		
SIP	2	Greater K'ichee7an	2.11
SAK	2		
KCH	2		
TZU	2		
KAQ	2		
USP	2		
PCH	2		
PQM	3		
QEQ	2		
Stability 3	**2.22**		
Stability 4	2.22		

Table 9. Stability Measures for pM *xa7 … 'Vomit'

Language	Stability 1	Subgroups	Stability 2
WAS	3	Wastekan	3.00
KAB	3		
YUK	0	Yukatekan	0.00
ITZ	0		
LAK	0		
MOP	0		
CHL	0	Greater Tzeltalan	0.00
YOK	0		
CHT	0		
CHR	0		
TZE	0		
TZO	0		
TOJ	0	Greater Q'anjob'alan	1.29
CHJ	0		
AKA	3		
POP	3		
QAN	3		
MCH	0		
TUZ	0		
TEK	3	Greater Mamean	3.00
MAM	3		
AWA	3		
IXL	3		
SIP	3	Greater K'ichee7an	3.00
SAK	3		
KCH	3		
TZU	3		
KAQ	3		
USP	3		
PCH	3		
PQM	3		
QEQ	3		
Stability 3	**1.69**		
Stability 4	**2.45 (minus Yu and GTz) (Minus Yu and GTz)**		

Next, we present the results of this study based on the application of this metric.

5. Results

5.1 Stability measures and word lists

Appendices 2–3 presents the Stability 3 and Stability 4 scores for the 50 Mayan anatomical etyma reconstructible to pM, LpM, and pCM. Appendix 6 provides the full dataset for all the variables examined in this paper, including the Stability 3 and 4 measures.

An obvious question is how Stability 3 and 4 measures compare to the ranked Leipzig-Jakarta and Swadesh word lists. Table 10 shows the subset of the Mayan etyma that overlap with the equivalent items in the Leipzig-Jakarta word list (Tadmor, Haspelmath & Taylor 2010). An ordinal ranking of the S3 and S4 scores was prepared (S3 Rankings, S4 Rankings), in ascending order from the most stable to the least. The Leipzig-Jakarta word list is also ranked in ascending order from the most "basic" to the least. Consequently, if the two rankings were equivalent, a statistically significant, positive correlation would be expected between it and the S3/S4 Rankings. A Spearman (Rank) Correlation test, which calculates the relationship between two ordinal variables, was applied. The results, ($r(17) = 0.07$, $p = 0.783$), applied to the S3 Rankings scores and Leipzig-Jakarta rankings by means of the DATAtab online statistics calculator, indicate there is no statistically significant correlation. The same test, this time considering the S4 Rankings, yielded similar results ($r(17) = -0.01$, $p = 0.96$), pointing to the absence of a statistically significant correlation.

Table 11 shows the subset of the Mayan etyma that overlap with the equivalent items in the ranked Swadesh word list (Holman et al. 2008). As with the Leipzig-Jakarta list, the Swadesh list is ranked in ascending order according to decreasing stability. Thus, if the two sets of rankings were equivalent, a statistically significant, positive correlation would be expected between it and the S3/S4 Rankings. Also as with the case of the Leipzig-Jakarta word list, the results of a Spearman Correlation test ($r(21) = 0.22$, $p = 0.321$), applied to the S3 Rankings and Swadesh rankings, indicate there is no statistically significant correlation. The same test, this time considering the S4 Rankings, yielded similar results ($r(21) = 0.19$, $p = 0.377$), also indicating that there is no statistically significant correlation.

The correlation tests for both the Swadesh and Leipzig-Jakarta rankings could suggest that Mayan languages are simply behaving in a family-specific, particularistic manner. When Stability 3 and 4 measures were tested for a relationship

Table 10. Subset of Mayan Etyma Overlapping Leipzig-Jakarta Word List Counterparts

No.	Etyma	Stage	Gloss	S3 rankings	S4 rankings	Leipzig-Jakarta
13	*ŋiiʔ ~ *ŋuuʔ	pM	nose; tip/point	20	34	2
35	*tyiiʔ	LpM	mouth	12	12	5
40	*ʔaaq'/*ʔaaʔq'	LpM	tongue	2	1	6
1	*b'aaq	pM	bone	4	4	7
7	*kik'	pM	blood	9	9	7
33	*tʃu(u)ʔ	LpM	women's breast	25	16	12
45	*ʔiim	pM	women's breast/ bosom	29	32	12
22	*ʃiik'	pM	wing	13	14	17
16	*q'ab'	pM	hand, arm	6	5	19
23	*ʃikin	LpM	ear	5	2	22
11	*nuuq'	pM	neck	29	27	23
24	*ʃiʔ	pM	hair; hair of head	36	33	31
43	*ʔaqan	pM	foot, leg	19	25	37
49	*ʔooq	LpM	foot, leg	20	29	37
50	*ʔuuk'aaʔ	pM	horn	17	10	38
28	*ts'uhuum	pCM	skin, hide	18	21	67
42	*ʔaaʔ	pCM	thigh	27	28	76
4	*Haty (weak h)	pM	eye, face; fruit	8	7	83
12	*ŋeeh	pM	tail	1	1	84

with the nominal variable "Basicness SLJ," defined on the basis of overlap (or lack thereof) between the Mayan anatomical vocabulary items and their counterparts in both the Swadesh and Leipzig-Jakarta lists, and thus on the basis of a dichotomous (Yes = 1, No = 2) variable, a different result is obtained. Table 12a provides the descriptive statistics relevant to Stability 3 and Basicness SLJ, indicating higher Stability 3 scores for items showing overlap (*Mean* = 1.58) than for those not (*Mean* = 0.99). The results of a Point Biserial Correlation test ($r_{pb} = -0.39$, $n = 50$, $p = .005$), show a statistically significant, negative correlation (i.e., the higher the S3 score, the more likely it is to correlate with Yes = 1 = Basic). Table 12b presents the descriptive statistics for Stability 4 with respect to the Basicness SLJ variable.

Table 11. Subset of Mayan Etyma Overlapping Ranked Swadesh Word List Counterparts

No.	Etyma	Stage	Gloss	S3 rankings	S4 rankings	Swadesh
23	*ʃikin	LpM	ear	5	2	4
4	*Haty (weak h)	pM	eye, face; fruit	8	7	8
44	*ʔeeh	LpM	tooth; edge	11	11	15
33	*tʃu(u)ʔ	LpM	women's breast	25	16	16
45	*ʔiim	pM	women's breast/bosom	29	32	16
1	*b'aaq	pM	bone	9	9	19
40	*ʔaaq'/*ʔaaʔq'	LpM	tongue	2	1	20
28	*ts'uhuum	pCM	skin, hide	18	21	21
7	*kik'	pM	blood	4	4	26
50	*ʔuuk'aaʔ	pM	horn	17	10	27
13	*ŋiiʔ ~ *ŋuuʔ	pM	nose; tip/point	20	34	31
24	*ʃiʔ	pM	hair; hair of head	36	33	37
37	*wiʔ	LpM	head; hair (of head)	31	44	37
17	*q'an, *q'an-al	pM	fat	30	24	45
2	*b'ah	**pCM**	head; first; reflexive; top	16	23	53
38	*xool-oom	LpM	head	28	41	53
43	*ʔaqan	pM	foot, leg	19	25	55
49	*ʔooq	LpM	foot, leg	20	29	55
35	*tyiiʔ	LpM	mouth	12	12	57
47	*ʔiSk'aq	pM	nail/claw/hoof	3	3	62
11	*nuuq'	pM	neck	29	27	83
12	*ŋeeh	pM	tail	1	1	86
14	*paam	pM	belly	32	15	96

This time, the results of a Point Biserial Correlation test ($r_{pb}=-0.44$, $n=50$, $p=.001$) also point to a statistically significant, negative correlation.

Overall, then, while the Stability 3 and 4 scores for the Mayan etyma in this study bear no particular correlation with the *rankings* for the items in the Leipzig-Jakarta or Swadesh lists, Mayan etyma with high stability scores do correlate, in general, with items present ("Yes" value) in such lists.

Table 12. Distribution of Stability 3 and 4 Scores with Respect to Basicness SLJ

a. Distribution of Stability 3 scores with respect to Basicness SLJ (Yes vs. No)

		N	**Mean**	**Median**	**Standard deviation**
Stability 3	No	24	1.01	1.02	0.58
	Yes	26	1.6	1.44	0.79

b. Distribution of Stability 4 scores with respect to Basicness SLJ (Yes vs. No)

		N	**Mean**	**Median**	**Standard deviation**
Stability 4	No	24	1.31	1.22	0.54
	Yes	26	1.89	1.9	0.65

5.2 Mayan languages and subgroups

Figure 4 illustrates the average Stability 1 scores for all etyma across all Mayan languages, while Table 13 presents the descriptive statistics. Tzeltal (ISO-639-3 tzh) exhibits the highest average Stability 1 score, 1.88, and Yokot'an/Chontal (ISO-639-3 chf) the lowest, 0.73. Appendix 7 provides the datasets for stability scores for all individual languages, and Appendix 8 for subgroups. It is possible that the high average Stability 1 score for Tzeltal could be the result of Kaufman's personal documentation of that language; nevertheless, Kaufman also conducted extensive documentation of Mochó, Ixil, and Tuzanteko, which exhibit much lower scores. Thus, we have assumed this to not be a factor. To determine whether the differences in S1 scores for individual etyma across the Mayan language family are significant, a Friedman Test was conducted; it treats the languages as distinct (repeated) "measurements" of the stability of an etymon, seeking to determine whether the factor differing across measurements (i.e., language) has an effect on the stability scores. The results ($X^2 = 43.45$, $N = 51$, $df = 31$, $p = 0.068$) suggest there are no significant differences across languages (i.e., "measurements"), although the results of post-hoc pairwise comparisons by means of a Dunn-Bonferroni test suggested the possibility of three significant pairwise comparisons, all three of them involving Tzeltal (with respect to Lakantun, Yokot'an, and Sipakapense, respectively). When the Friedman Test was applied with only these four languages as repeated measurements, the results ($X^2 = 17.75$, $N = 51$, $df = 3$, $p < .001$) are statistically significant and the differences between the pairwise comparisons involving Tzeltal and the rest are also significant.

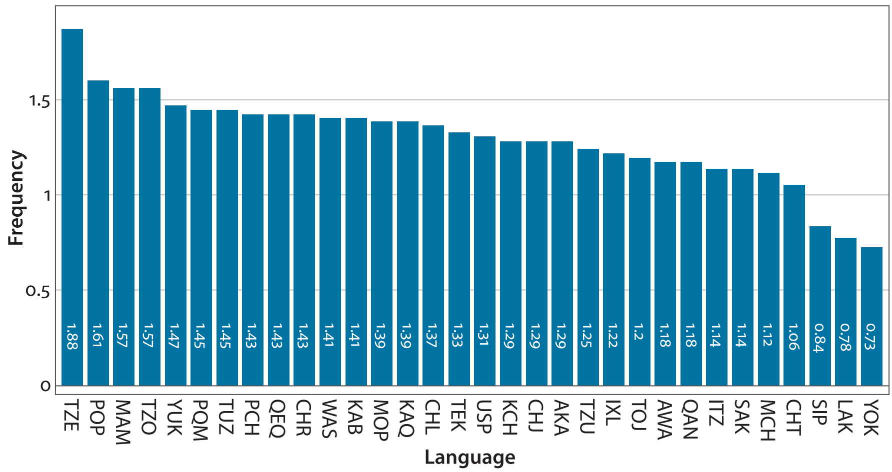


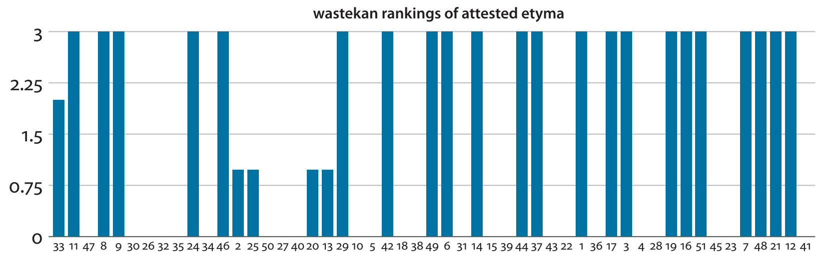
Figure 4. Average Stability 1 Scores for All Languages Sorted in Descending Order, Prepared with DATAtab

Table 13. Descriptive Statistics for Average Stability 1 Values of All Languages

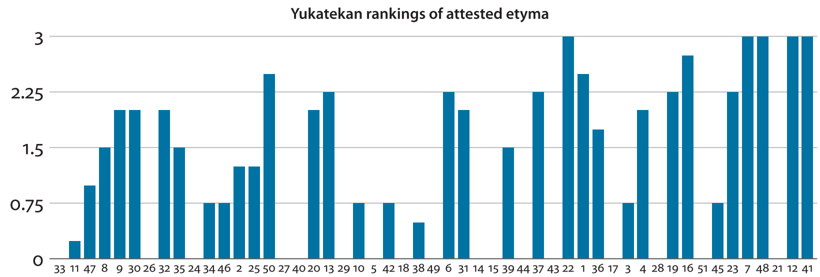
	Average Stability 1
Mean	1.3
Std. Deviation	0.24
Minimum	0.73
Maximum	1.88
95% Confidence interval of Mean	1.22; 1.38
Mean ± Std.	1.3 ± 0.24

The various subgroups differ, as is to be expected, in the stability scores for individual etyma. Figure 5 presents the data for three of the subgroups, the first one of which (Yukatekan), is sorted by descending stability measures.

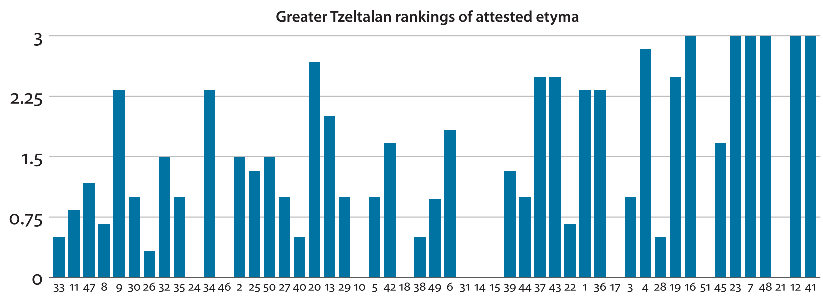
a.


wastekan rankings of attested etyma
3
2.25
1.5
0.75
0
33 11 47 8 9 30 26 32 35 24 34 46 2 25 50 27 40 20 13 29 10 5 42 18 38 49 6 31 14 15 39 44 37 43 22 1 36 17 3 4 28 19 16 51 45 23 7 48 21 12 41

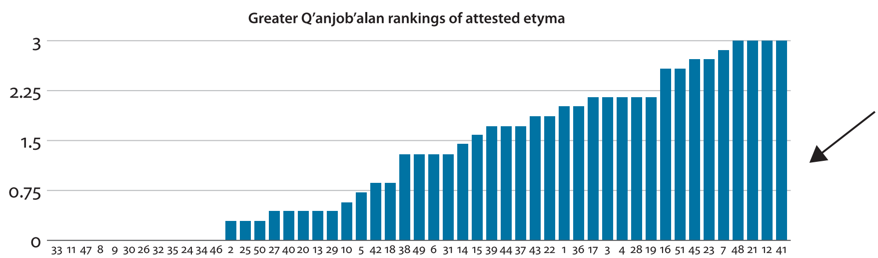
b.


Yukatekan rankings of attested etyma
3
2.25
1.5
0.75
0
33 11 47 8 9 30 26 32 35 24 34 46 2 25 50 27 40 20 13 29 10 5 42 18 38 49 6 31 14 15 39 44 37 43 22 1 36 17 3 4 28 19 16 51 45 23 7 48 21 12 41

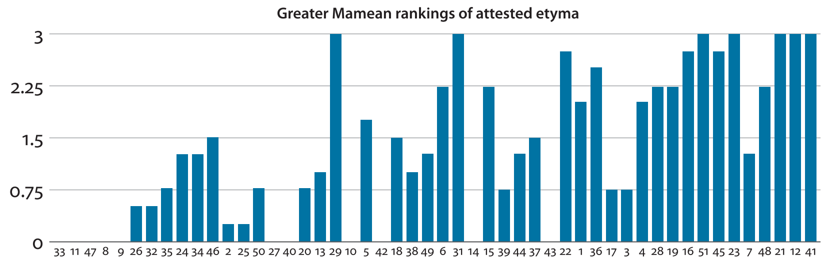
c.


Greater Tzeltalan rankings of attested etyma
3
2.25
1.5
0.75
0
33 11 47 8 9 30 26 32 35 24 34 46 2 25 50 27 40 20 13 29 10 5 42 18 38 49 6 31 14 15 39 44 37 43 22 1 36 17 3 4 28 19 16 51 45 23 7 48 21 12 41

d.


Greater Q'anjob'alan rankings of attested etyma
3
2.25
1.5
0.75
0
33 11 47 8 9 30 26 32 35 24 34 46 2 25 50 27 40 20 13 29 10 5 42 18 38 49 6 31 14 15 39 44 37 43 22 1 36 17 3 4 28 19 16 51 45 23 7 48 21 12 41

e.



f.

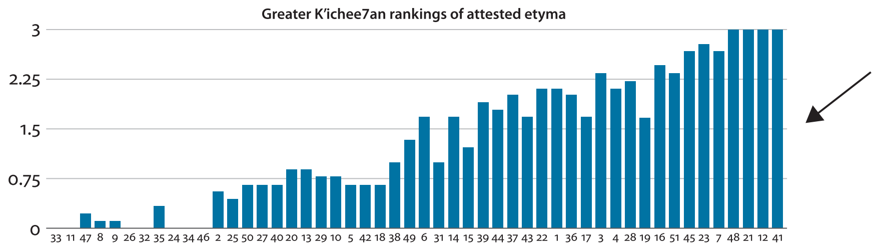


Figure 5. Stability 2 scores for three of the six Mayan subgroups, sorted according to Yukatekan: (a) Wastekan, (b) Yukatekan, (c) Greater Tzeltalan, (d) Greater Q'anjob'alan, (e) Greater Mamean, (f) Greater K'ichee7an; prepared with Apple Numbers

Table 14 presents the descriptive statistics for the Stability 2 (subgroup) measures for all 50 etyma across each subgroup.

Table 14. Descriptive Statistics for the Stability 2 Scores of the Six Major Subgroups

	Wa	Yu	GTz	GQ'	GM	GK'
Mean	1.44	1.18	1.35	1.26	1.35	1.31
Median	1	0.88	1.09	1.29	1.25	1.11
Std. Deviation	1.45	1.09	1.04	1.05	1.09	0.98
Minimum	0	0	0	0	0	0
Maximum	3	3	3	3	3	3
Range	3	3	3	3	3	3
Mean ± Std.	1.44 ± 1.45	1.18 ± 1.09	1.35 ± 1.04	1.26 ± 1.05	1.35 ± 1.09	1.31 ± 0.98

To determine whether there is a statistically significant difference in the Stability 2 measures among the subgroups, a non-parametric Friedman Test was carried out. The results ($X^2(5) = 5.66$, $p = 0.34$), and the pairwise comparisons between subgroups, presented in Table 15, suggest no statistically significant differences among the subgroups.

Table 15. Results of Friedman Test Applied to S2 Scores for Subgroups*

	Test statistics	Standard error	Std. test statistics	p	Adj. p
Wa – Yu	0.26	0.37	0.69	.487	1
Wa – GTz	−0.38	0.37	−1.02	.31	1
Wa – GQ'	0.45	0.37	1.2	.229	1
Wa – GM	0.17	0.37	0.45	.65	1
Wa – GK'	0.16	0.37	0.43	.669	1
Yu – GTz	−0.64	0.37	−1.71	.087	.523
Yu – GQ'	0.19	0.37	0.51	.612	1
Yu – GM	−0.09	0.37	−0.24	.81	1
Yu – GK'	−0.1	0.37	−0.27	.789	1
GTz – GQ'	0.83	0.37	2.22	.027	.159
GTz – GM	0.55	0.37	1.47	.142	.849
GTz – GK'	0.54	0.37	1.44	.149	.894
GQ' – GM	−0.28	0.37	−0.75	.454	1
GQ' – GK'	−0.29	0.37	−0.78	.438	1
GM – GK'	−0.01	0.37	−0.03	.979	1

* In each row, the null hypothesis is tested if both samples are the same, the "Adj. p-value" is obtained by multiplying the p-value by the number of tests.

A different question that is worth addressing is whether some subgroups are more like other specific subgroups as far as their respective scores for individual etyma. A non-parametric, Spearman Correlation Analysis was carried out to assess whether there exist statistically significant correlations between pairs of subgroups in terms of the stability scores for all etyma across the subgroups. This test only compares S2 scores, *not the actual polysemies or changes*. The results are seen in Table 16: the correlations with statistical significance ($p = \leq 0.05$) are italicized, and those pairs of correlations with high or very high positive correlations ($r = 0.5 < 0.7$, high; $r = 0.7 < 1$, very high) are shown in **bold** (Yukatekan and Greater Tzeltalan), <u>underlined</u> (Greater K'ichee7an and Greater Mamean), ***bold and italics*** (Greater Mamean and Greater Q'anjob'alan), and <u>**bold and underlined**</u> (Greater K'ichee7an and Greater Q'anjob'alan).

It may be suggested that the high, positive correlation between Yu and GTz could be due to the centuries of close interaction in the GLL and LL diffusion zones. The high, positive correlation between GK' and GM could be due to both their close phylogenetic affiliation, both descending directly from the Eastern Mayan grouping, and their geographic proximity, which would have pro-

Table 16. Results of Spearman Correlation Analysis Comparing S2 Scores Across Subgroups

		Wa	Yu	GTz	GQ'	GM	GK'
Wa	Correlation	1	0.05	0.05	0.14	0.05	0.14
	p (2-tailed)		.708	.723	.343	.753	.348
Yu	Correlation	0.05	1	**0.72**	0.27	0.29	0.35
	p (2-tailed)	.708		*<.001*	.059	*.042*	*.014*
GTz	Correlation	0.05	**0.72**	1	0.33	0.18	0.38
	p (2-tailed)	.723	*<.001*		*.019*	.212	*.007*
GQ'	Correlation	0.14	0.27	0.33	1	***0.65***	0.97
	p (2-tailed)	.343	.059	*.019*		*<.001*	*<.001*
GM	Correlation	0.05	0.29	0.18	***0.65***	1	0.65
	p (2-tailed)	.753	*.042*	.212	*<.001*		*<.001*
GK'	Correlation	0.14	0.35	0.38	0.97	0.65	1
	p (2-tailed)	.348	*.014*	*.007*	*<.001*	*<.001*	

moted communication. The high, positive correlation between GQ' and GM, two subgroups belonging to different groupings, Western Mayan and Eastern Mayan, respectively, could be in part due to contact in the Huehuetenango diffusion zone involving Mamean Proper (Mam, Teko) and Q'anjob'alan Proper (Q'anjob'al, Akateko, Popti7, Mochó, Tuzanteko) (Kaufman 2017: 69). Nevertheless, the *very high*, positive correlation between GK' and GQ', already noted earlier (recall Figures 5d and 5f) subgroups belonging to different groupings, Eastern Mayan and Western Mayan, respectively, was a surprise, as these groupings are not particularly closely related, nor are they known to have experienced significant diffusion between them. They are, and have long been, separated geographically by the GM languages. If this is the case, one may wonder whether these two subgroups were especially conservative in terms of lexico-semantic stability, given the very high correlation between their stability scores. Nevertheless, a look at Table 14 will remind us that it is Wa, GTz, and GM that exhibit the highest mean Stability 2 scores, not GQ' and GK', and also, the statistical test to determine whether the mean Stability 2 scores (across subgroups) were significantly different supported the null hypothesis, i.e., no significant difference. Given such results, it is not clear why GQ' and GK' exhibit a very high, positive correlation.

We also carried out a Hierarchical Cluster Analysis (HCA) for both all the languages and the subgroups according to the stability scores (Average S1, S2) for all etyma across all languages and subgroups; Appendix 9 provides the languages dataset (S1 scores for all etyma across all languages), and Appendix 10 the one for the subgroups (S2 scores for all etyma across all subgreoups). The results are presented in full in Appendix 11. Here we provide the resulting dendrograms. Figure 6 presents the HCA dendrograms for average stability scores for each language for all etyma, with Figure 6a showing the dendrogram for the Weighted pair-group, Squared Euclidean HCA, and Figure 6b for the Unweighted pair-group, Squared Euclidean HCA.

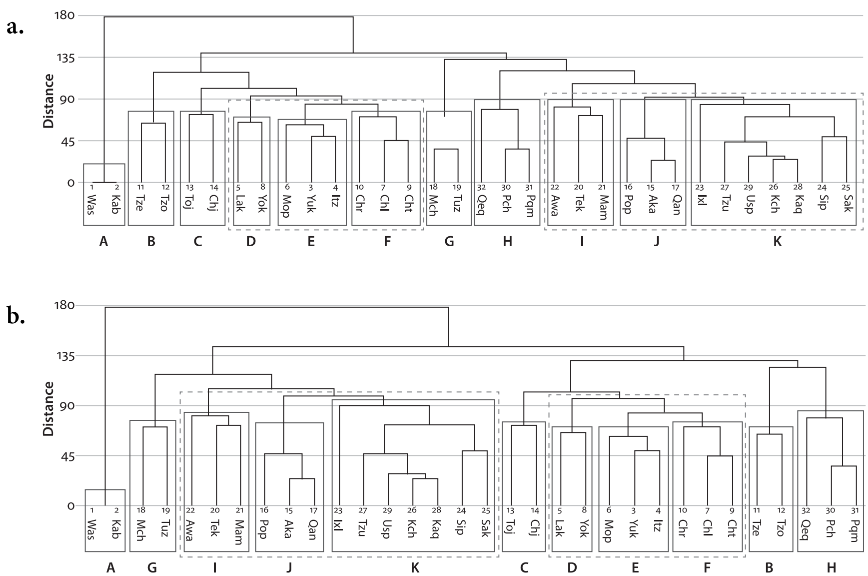


Figure 6. HCA dendrograms for all Etyma across individual languages: Prepared with StatPlus for Mac, and labeled to indicate low-level (solid rectangles) and higher-level (dashed rectangles) clusters

The lower-level clusters resulting from these analyses are thoroughly consistent with the smaller subgroupings in Kaufman's (2017) phylogentic model. However, there were some "odd" pairs or individual languages: Ixil (within cluster K) is clustered with several Greater K'ichee7an languages instead of with Greater Mamean; Lakandon and Yokot'an (cluster D) are clustered together, instead of Lakandon appearing immediately clustered with other Yukatekan languages, or Yokot'an with other Ch'olan or Greater Tzeltalan languages; and Mocho and Tuzantek (cluster G), while clustering with each other as expected, appear rather distant from other Greater Q'anjob'alan languages. We suspect this is due to these languages being less thoroughly documented (Ixil, Tuzantek), having experienced more polysemy/shift or lexical replacement/loss than others (Lakandon, Yokot'an, Mochó), or perhaps unexpected gaps during our data collection process (Yokot'an).

Presumably, excessive gaps in our data, whatever their cause, would result in lower stability scores for these languages. We decided to test this; languages were divided into "odd" and "expected" categories according to their placement in the HCA dendrograms, and their Means and Standard Deviations for stability scores were assessed, as seen in Table 17, indicating that the languages with odd placement exhibit lower Stability values ($M = 1.06$, $SD = 0.3$) than the languages with expected placement ($M = 1.34$, $SD = 0.2$). A simple t-Test for Independent Samples to determine whether languages with "odd" placements in the HCA dendrograms correlate with lower stability scores was applied, and the results ($t(30) = -2.71$, $p = 0.011$, 95% confidence interval [−0.5, −0.07]), presented in Table 18, suggest that there is in fact a statistically significant difference.

Table 17. Descriptive Statistics for Language Categories "Odd" and "Expected" According to Stability Measures

		N	Mean	Std. deviation	Std. error mean
Average S1	Odd	5	1.06	0.3	0.14
	Expected	27	1.34	0.2	0.04

Table 18. t-Test for Independent Samples Results

		t	df	p (2-tailed)
Average S1	Equal variances	−2.71	30	.011
	Unequal variances	−2.02	4.66	.104

We also carried out similar analyses at the subgroup level (Stability 2 scores). The full analyses are found in Appendix 11, and the resulting HCA dendrograms are seen in Figure 7. The very high, positive correlation between GQ' and GK' translates to a very low Node distance (2.54) between them, whereas that between GM and GQ'-GK' cluster is 35.74. Also, both dendrograms link Yu and GTz (Node distance 32.19), a result likely reflecting their membership in the Greater Lowland Mayan contact area, as already discussed.

The low-level clusters largely agree with Kaufman's (and others') classification of low-level groupings within the Mayan family based on phonological, morphological, and syntactic traits. And some of the higher-level clusters may very well correspond to a combination of both contact diffusion and phylogenetic descent. Consequently, it appears that, with further refinement, the lexico-semantic stability metric could offer a very useful approach to study both subgrouping and language contact.

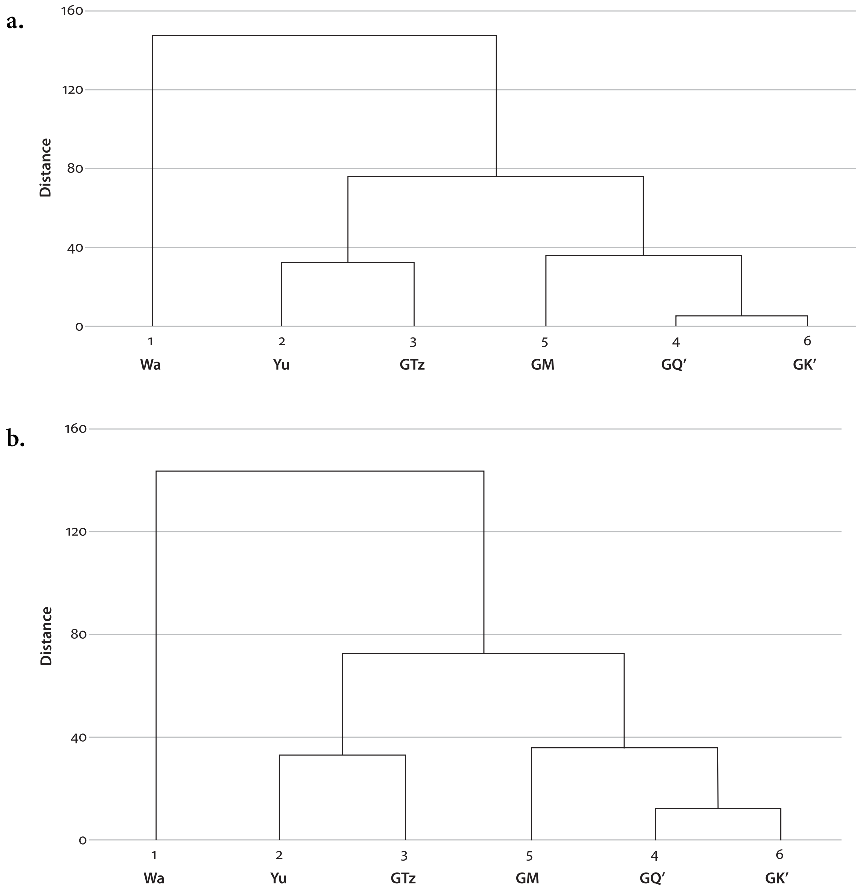


Figure 7. Subgroup dendrograms: (a) Weighted, (b) Unweighted; prepared with StatPlus for Mac

5.3 Other variables

It is to be expected that stability measures would correlate with Stage (pM, LpM, CM). After determining the data (Appendix 6) to be normally distributed, we decided to apply a parametric test, more specifically, an Analysis of Variance (ANOVA) that determines whether the differences between more than two samples are statistically significant. The descriptive statistics for the stability measures across the respective stages are shown in Table 19. Figure 8 represents this distribution graphically.

The ANOVA yielded results ($F = 4.21$, $p = 0.021$), seen in more detail in Table 20, showing that there is a statistically significant difference between his-

Table 19. Descriptive Statistics of Stability 3 Scores with Respect to Stages

		Stage		
		pM	**pCM**	**LpM**
	Frequency	28	10	12
Stability 3	Mean	1.45	0.74	1.49
	Median	1.23	0.72	1.38
	Std. Deviation	0.74	0.34	0.83
	Range	2.69	1.1	2.43
	Mean ± Std.	1.45 ± 0.74	0.74 ± 0.34	1.49 ± 0.83

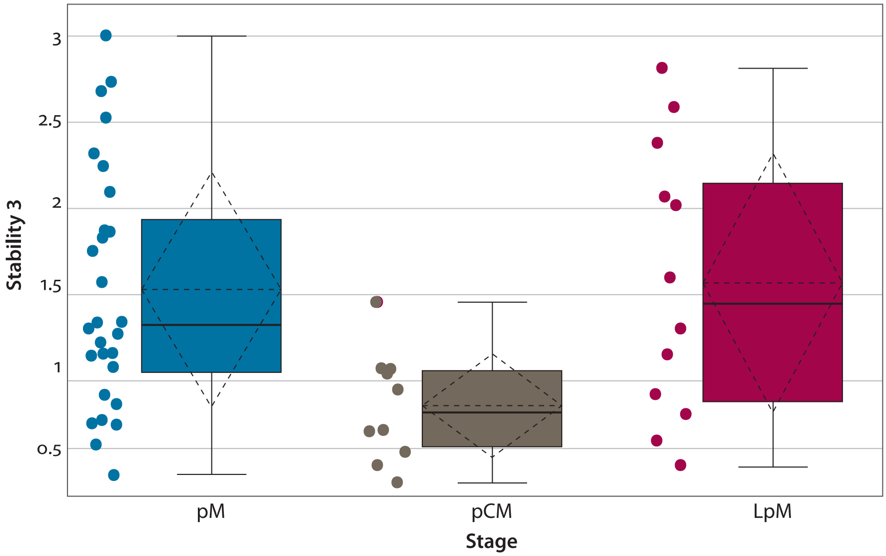


Figure 8. Box Plot of Distribution of Stability Scores with Respect to Historical Stages; prepared with DATAtab

torical stages with respect to the Stability 3 measure. The results of a Dunn-Bonferroni post-hoc test, which conducts pairwise comparisons of the groups to determine out which were significantly different, are seen in Table 21, revealed that the pairwise group comparisons of LpM – pCM and pM – pCM have a *p*-value of less than 0.05. Thus, based on the available data, it can be assumed that these pairs are each significantly different, while the pairwise group comparison of pM – LpM did not. This result could suggest that it is possible to merge pM and LpM into a single category, and more specifically, that the effect of the

Wastekan data is not very significant at all, since LpM is defined as pM minus Wastekan. This could also suggest that a less restrictive differentiation of proto-Mayan into three groups – Wastekan, Yukatekan, and the rest (Central Maya) – could be entertained, at least based on the data presented in this paper.

Table 20. Results of ANOVA of Stages with Respect to Stability 3 Scores

	Sum of squares	df	Mean squares	F	p	Critical F-value
Between Groups	4.18	2	2.09	4.21	.021	3.2
Within Groups	22.35	47	0.5			
Total	**27.53**	**49**				

Table 21. Results of Bonferroni Post-Hoc Test

		Mean diff.	Std. error	p	95% CI lower limit	95% CI upper limit
pM	pCM	0.71	0.26	.027	0.06	1.36
pM	LpM	−0.05	0.243	1	−0.65	0.56
pCM	LpM	−0.75	0.302	.048	−1.51	0

Another question worth addressing is whether the stability measures can be shown to be associated with independent variables such: Type of Anatomy, Part or Function, or Area of the Body. Mann-Whitney U-Tests were applied with DATAtab to both Stability 3 and 4 measures and the Type of Anatomy variable (General vs. Nonhuman). In both cases, the Nonhuman category exhibits higher values than the General category, as seen in Table 22, and illustrated in Figure 9. While the test results for Stability 3 (Table 23a, $U=26.5$, $p=0.072$, $r=0.25$) suggest no statistically significant relationship, the test results for Stability 4 (Table 23b, $U=21.5$, $p=0.045$, $r=0.28$) do show a statistically significant relationship, with a p-value below 5%. This means that, once the effect of lexical replacement/loss is removed, etyma referring to anatomical parts not relevant to humans ('tail', 'wing', 'horn') are more stable, though, in fairness, the dataset of 50 etyma contains only 3 such cases.

We also assessed whether the Area of the Body variable influenced the stability scores. Table 24 provides the descriptive statistics for this variable for both Stability 3 and 4 scores: the "mouth" area exhibits higher values (*Mean* = 1.81, Standard Deviation 0.71) than any other area with regard to Stability 3, and also with regard to Stability 5. The Analysis of Variance results ($F=1.4$, $p=0.227$) point to no significant difference between the "area of body" variable and Stability 3. The same test also yielded non-significant results ($F=0.83$, $p=0.584$) for the Stability 4

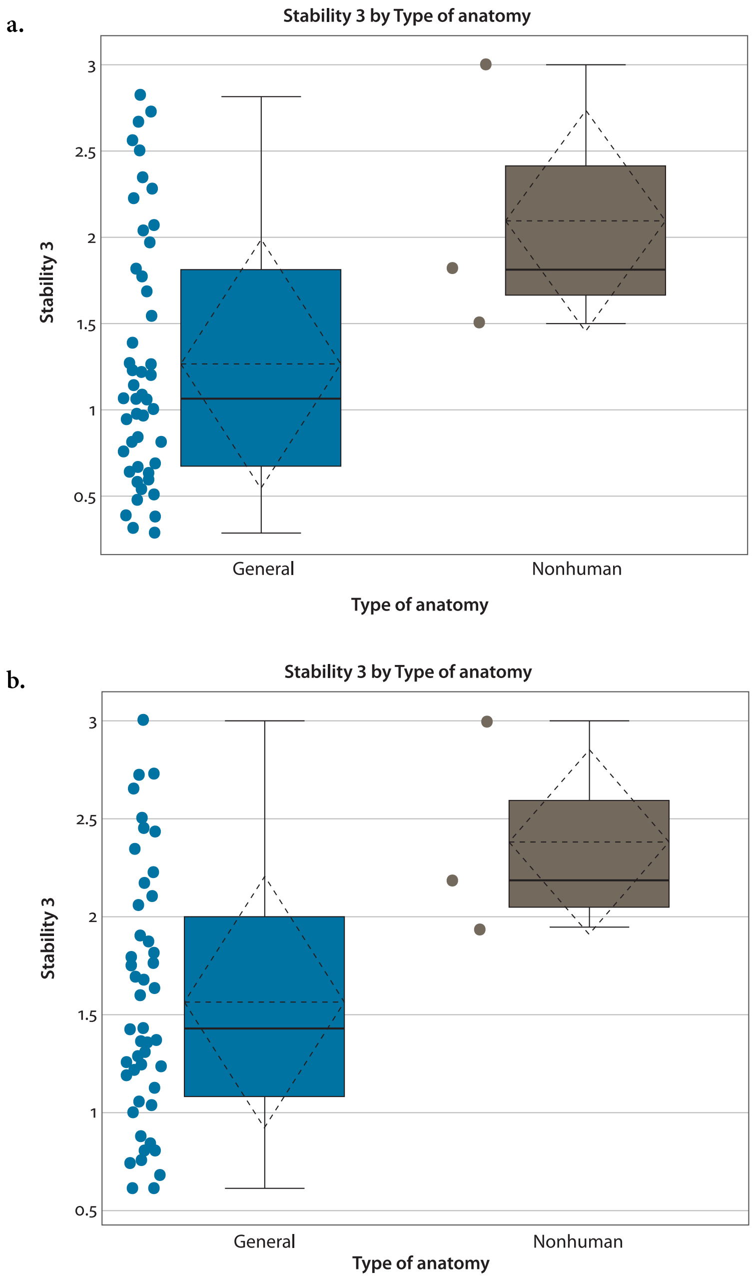


Figure 9. DATAtab

Table 22. Descriptive Statistics for Stability 3 and 4 Scores with Respect to the Variable 'Type of Anatomy' ('General' vs. 'Nonhuman')

a. Stability 3

	N	Mean	Median	Standard deviation
General	47	1.27	1.06	0.73
Nonhuman	3	2.1	1.81	0.79

b. Stability 4

	N	Mean	Median	Standard deviation
General	47	1.56	1.42	0.64
Nonhuman	3	2.37	2.18	0.56

Table 23. Mann-Whitney U-Test Statistics for Stability 3 and 4 Scores with Respect to 'Type of Anatomy'

a. Stability 3 scores

	Values
Mann-Whitney U	26.5
Z	−1.8
Asymptotic Significance (2-tailed)	.072
Exact Significance (2-tailed)	.077

b. Stability 4 scores

	Values
Mann-Whitney U	21.5
Z	−2
Asymptotic Significance (2-tailed)	.045
Exact Significance (2-tailed)	.048

measure. Thus, the area of the body does not appear to be of importance to either Stability 3 or 4 measure.

Finally, we also assessed whether the variable Part or Function showed an interaction with either Stability 3 or 4 scores. Table 25 shows the descriptive statistics relevant to the Stability 3 and 4 scores. In both cases, the Function variant shows higher values for Stability (3/4) than the Part variant. However, the results

Table 24. Descriptive statistics for stability 3 and 4 with respect to part/function variable: Data are sorted according to stability 3 mean values

	Stability 3			Stability 4		
	N	**Mean**	**Std. deviation**	**N**	**Mean**	**Std. deviation**
Mouth	8	1.81	0.71	8	2.02	0.69
Whole body	5	1.61	0.8	5	1.85	0.61
Limb	7	1.55	0.84	7	1.72	0.69
Nose	3	1.42	0.32	3	1.42	0.32
Rear	5	1.41	1.03	5	1.62	0.84
Head	8	1.09	0.73	8	1.42	0.73
Face	6	0.98	0.7	6	1.44	0.69
Torso	6	0.86	0.18	6	1.41	0.43
Pelvis	2	0.74	0.64	2	1.14	0.76
Total	**50**	**1.3**	**0.73**	**50**	**1.59**	**0.64**

of the Mann-Whitney U-Test involving the Stability 3 scores ($U=127$, $p=0.146$, $r=0.21$) indicate no statistically significant difference. Similarly, the results of the Mann-Whitney U-Test involving Stability 4 scores ($U=148.5$, $p=0.363$, $r=0.13$) indicate no statistically significant difference.

Table 25. Descriptive Statistics for Stability 3 and 4 Scores with Respect to Part/Function Variable

a. Stability 3

	N	**Mean**	**Median**	**Std. deviation**
Function	9	1.64	1.78	0.73
Part	41	1.25	1.06	0.74

b. Stability 4

	N	**Mean**	**Median**	**Std. deviation**
Function	9	1.78	1.81	0.69
Part	41	1.57	1.42	0.66

5.4 A Mayan-specific assessment of basicness and stability

At least as far as the anatomical domain is concerned, Figure 10 can be regarded as a schematic representation of the combined [±basic, ±stable] variables, with stability defined on the basis of Stability 3 scores (>1.5=[+stable]). Pairs of etyma with the same or a similar proto-gloss were given numerical subindices to distinguish them.

		Stable	
		+	–
Basic	+	tail, tongue, nail/claw/hoof, blood, ear, hand/arm, eye/face/fruit, bone, tooth/edge, mouth, wing, head	hair/head hair, belly, head/head hair, fat, women's breast$_1$, neck, head/first/reflexive/top, thigh, women's breast$_2$, nose/tip/point, foot/leg$_1$, foot/leg$_2$, skin/hide, horn
	–	spit(tle), belch, fart, sneeze, vomit	urine, brains, eyebrow, left hand, cheek, arse$_1$, molar tooth, arse$_2$, facial hair/corn silk, corner/side, hiccup, belly/stomach, penis, sideways, non-head hair, eyelash(es), forehead, excrement, mucus

Figure 10. Mayan anatomical Etyma categorized as [±basic, ±stable]: Stability is defined on the basis of Stability 3 scores (>1.5=[+stable]); [+basic] is based on overlap with both Swadesh and LJ lists (Basicness SLJ)

The items in the [+basic, +stable] class, as argued by Ratliff (2006: 1–2), would provide the "greatest value in evaluating competing claims for distant relationship," she continues, given that "it is reasonable to assume that some of these words were stable at a time that antedates the protolanguage of the established family as well." Mora-Marín (2016) has recently presented evidence in favor of a remote phylogenetic relationship between Mayan and Mixe-Zoquean languages. Of the [+basic, +stable] items in Figure 9, only a few appear as strong candidates for cognacy: hand/arm, bone, and wing. Of the [+basic, –stable] items, the following are present: hair/head hair, neck. Of the [–basic, +stable] items, all were similar but not studied due to the high likelihood that they could be onomatopoeic. Finally, of the [–basic, –stable] items, none are present in the list of potential cognates. The [+basic] items thus appear to be the most useful in such comparison, not surprisingly.

For Matisoff (2009: 292), the items in the [+basic, –stable] class could be "especially useful for establishing isoglosses among subgroups of a language family." Interestingly, this category bears several examples, three pairs to be precise, of etyma with very close or identical meanings: HAIR/HEAD HAIR vs. HEAD/HEAD

HAIR, WOMEN'S BREAST$_1$ vs. WOMEN'S BREAST$_2$, and FOOT/LEG$_1$ vs. FOOT/LEG$_2$. Perhaps one member of each pair became associated with negative connotations (taboo), and this contributed to its lower stability and increased its chance of replacement. The [–basic, –stable] category also bears a similar example: ARSE$_1$ vs. ARSE$_2$.

5.5 Polysemies and subgrouping

Our datasets allow for a closer examination of polysemies and to assess whether specific cases of polysemies correlate with specific subgroupings. Preliminary results suggest that this is a very productive avenue of research. For each etymon, we have prepared matrix tables matching all attested meanings to languages (cf. Appendix 5). Both [+stable] and [–stable] etyma are amenable to this type of investigation; what matters is that the etymon in question bears multiple meanings. For instance, pM *Haty 'eye, face; fruit', bears a variety of meanings, as seen in Table 26. The meaning 'inside' is attested exclusively among the Yukatekan languages, while the meaning 'forehead' is shared exclusively by four of the nine Greater K'ichee7an languages. Similarly, the meaning 'buttocks' for pM *7iit 'arse; bottom' is restricted to three of the six Greater Tzeltalan languages and Q'eqchi', a Greater K'ichee7an language, but one that has borrowed significant amounts of vocabulary from Ch'olan languages. The case of pCM *7aa7 'thigh' is also clear; the additional meaning 'leg' is attested exclusively among eight of the nine Greater K'ichee7an languages, strongly suggesting that this polysemy was a proto-Greater K'ichee7an innovation. The same can be argued for the meanings 'man' and 'male' of pM *7aaty 'penis': such meanings are exclusive to Greater K'ichee7an as well, and are likely an innovation of proto-Greater K'ichee7an. In a future paper we will assess the entire dataset for this type of information in much more detail, but for now, what is crucial is that the correlation of specific polysemies and shifts, more than stability scores, seems to be a more useful approach to testing subgrouping models.

We decided to test whether stability scores correlate with the number of meanings per etymon. Table 27 presents the relevant descriptive statistics, where Polysemy refers to the number of attested meanings for each etymon. A Spearman Correlation test was carried out for each stability measure with respect to polysemy. With regard to Stability 3, the results of the test ($r(48) = -0.05$, $p = 0.715$) point to *no* statistically significant relationship. Similarly, with regard to Stability 4, the results of the test ($r(48) = -0.22$, $p = 0.132$) also point to no statistically significant relationship. Thus, we conclude that stability scores, per se, are not the important measure for studying subgrouping, but instead, polysemy scores. This constitutes a partial departure from Matisoff's (2009) approach, which argued for the [+basic, –stable] etyma as especially relevant for subgrouping. It is a partial

Table 26. Meaning/Language Matrix for pM *Haty 'Eye, Face; Fruit'

Language	Eye	Face	Fruit	Inside	Forehead	Color	Width	Surface	Sight	Class	Totals
WAS	0	0	0	0	0	0	0	0	0	0	**0**
KAB	0	0	0	0	0	0	0	0	0	0	**0**
TEK	1	1	0	0	0	0	0	0	0	0	**2**
MAM	1	1	0	0	0	0	0	0	0	0	**2**
AWA	1	1	0	0	0	0	0	0	0	0	**2**
IXL	1	1	0	0	0	0	0	0	0	0	**2**
SAK	0	1	0	0	0	0	0	0	0	0	**1**
PCH	1	1	1	0	0	0	0	0	0	0	**3**
QEQ	1	1	0	0	0	0	0	0	0	0	**2**
TOJ	1	1	1	0	0	0	0	0	0	0	**3**
CHJ	1	1	1	0	0	0	0	0	0	0	**3**
AKA	1	1	0	0	0	0	0	0	0	0	**2**
POP	1	1	1	0	0	0	0	0	0	0	**3**
QAN	1	1	1	0	0	0	0	0	0	0	**3**
MCH	1	1	1	0	0	0	0	0	0	0	**3**
TUZ	1	1	1	0	0	0	0	0	0	0	**3**
CHL	1	0	1	0	0	0	0	0	0	0	**2**
YOK	1	1	1	0	0	0	0	1	0	0	**4**
CHT	1	0	1	0	0	0	0	0	0	0	**2**
CHR	1	1	0	0	0	0	0	0	0	0	**2**
TZE	1	1	1	0	0	0	0	0	0	0	**3**
TZO	1	1	1	0	0	0	0	0	0	0	**3**
TZU	1	0	0	0	0	0	1	0	0	0	**2**
PQM	0	0	0	0	0	0	1	0	0	0	**1**
SIP	0	1	0	0	1	0	0	0	0	0	**2**
KCH	1	1	0	0	1	0	0	0	0	0	**3**
KAQ	1	1	0	0	1	0	0	0	0	0	**3**
USP	1	1	0	0	1	0	0	0	0	0	**3**
YUK	1	1	1	1	0	0	0	0	0	0	**4**
LAK	1	1	1	1	0	0	0	0	0	0	**4**
ITZ	1	1	1	1	0	1	0	0	1	0	**6**
MOP	1	1	1	1	0	1	0	0	0	1	**6**
Totals	**27**	**26**	**16**	**4**	**4**	**2**	**2**	**1**	**1**	**1**	

departure because the etyma that experience more polysemy are likely to be both [+basic, −stable] and [−basic, −stable]. But it is an important departure nonetheless, because, by definition, more polysemy implies more variation and potential for change, and thus, a more direct means of assessing subgrouping than stability scores, as one of the referees of this paper has acknowledged.

Table 27. Descriptive Statistics for Stability Measures with Respect to Polysemy Value

	Stability 3	Stability 4	Polysemy
Mean	1.32	1.61	3.98
Median	1.11	1.52	3
Modal	1.06	0.6	1
Std. Deviation	0.75	0.66	2.76
Minimum	0.28	0.6	1
Maximum	3	3	10
Range	2.72	2.4	9
Mean ± Std.	1.32 ± 0.75	1.61 ± 0.66	3.98 ± 2.76

Next, we decided to test whether there is a relationship between the Polysemy variable and the Part or Function variable. The descriptive statistics can be seen in Table 28. These show that etyma referring to parts (e.g., 'head', 'hand/arm', etc.) show higher Polysemy values than etyma referring to bodily functions or products (e.g., 'blood', 'sneezing'). The results of Mann-Whitney U-Test ($U=71$, $p=0.004$, $r=0.41$) point to a statistically significant difference, which means that etyma for functions/products are less likely to develop polysemy and experience shift. To our knowledge, this is not a topic that has been explored in prior literature, and in fact, very few such etyma appear in the Swadesh or Leipzig-Jakarta lists. It is thus worth exploring cross-linguistically, as such etyma could prove to be more stable.

Table 28. Descriptive Statistics for Polysemy Variable with Respect to Part/Function Variable

		N	Mean	Median	Standard deviation
Polysemy	Part	41	4.46	4	2.79
	Function	9	1.78	1	0.97

We checked whether there is a statistically significant relationship between Type of Anatomy (General, Nonhuman) with respect to polysemy scores. Table 29 provides the descriptive statistics, which show higher values of polysemy for the General category than for the Nonhuman category. The Mann-Whitney U-Test results ($U=21.5$, $p=0.043$, $r=0.29$) indicate that this difference *is* statistically significant: etyma referring to anatomical parts of non-humans exhibit significantly less polysemy and shift.

Table 29. Descriptive Statistics for Polysemy Variable with Respect to Type of Anatomy

		N	Mean	Median	Standard deviation
Polysemy	General	47	4.15	3	2.76
	Nonhuman	3	1.33	1	0.58

Finally, we tested whether Area of Body shows a statistically significant relationship with Polseymy. Table 30 provides the descriptive statistics. The Kruskal-Wallis Test results ($X^2(8) = 4.33$, $p = 0.826$) indicate there is no statistically significant difference among the areas of the body with respect to polysemy values.

Table 30. Descriptive Statistics for Area of Body with Respect to Polysemy

	N	Mean	Std. deviation
Whole body	5	6	4.06
Head	8	4.75	3.24
Nose	3	4	2.65
Face	6	3.83	3.25
Torso	6	3.83	1.33
Rear	5	3.2	1.79
Mouth	8	2.75	2.43
Limb	7	3.57	2.15
Pelvis	2	5	5.66
Total	**50**	**3.98**	**2.76**

6. Conclusions and future research

The paper has provided support to the importance of studying the anatomical domain. For one, it has supported, using data from the World Loanword Database, specifically from Tadmor, Haspelmath and Taylor's (2010) work on the Leipzig-Jakarta word list, the notion that such domain is among the most lexico-semantically stable. Crucially, the paper has introduced a novel metric for assessing lexico-semantic stability and semantic stability, and it has applied a variety of statistical tests to assess its utility. The metric is straightforward and objective, and it does not require difficult judgments and relative semantic distances between different meanings of a word along a presumed polysemy/shift continuum.

The results of this work have also highlighted the utility of Kaufman with Justeson's (2003) PMED. Indeed, the questions and methods explored in this paper could be applied to other semantic domains contained within it. The lexico-semantic stability metric, applied to the PMED, has resulted in tests of questions posed in the literature. It is clear that high stability scores in the selected vocabulary do correlate with "basicness" based on presence in both the Swadesh and Leipzig-Jakarta lists, but not with the specific stability rankings of those lists. It was also shown that stability scores can be used to develop hierarchical models to assess subgrouping, though it is likely that the results conflate evidence of actual subgrouping (innovations) with evidence from contact (diffusion), and it was even suggested that a less restrictive model for the differentiation of the Mayan family could be supported on the basis of stability scores; such a model would not warrant a strict sequence of binary splits at the early stages, but a more open branching out from the beginning, though this possibility remains to be tested further. Importantly, as a slight departure from Matisoff (2009), it is proposed that the most polysemous etyma, likely to include [+basic, −stable] and in principle [−basic, −stable] etyma, more so than stability scores based largely on [+basic, +stable] and [−basic, +stable], ought to be used for assessing subgroupings – though the present paper has only hinted at how to go about doing this. In addition, several results relevant to the Mayan data, including the importance of terms for bodily functions/fluids, should be tested against cross-linguistic data and explored further.

Our next steps will include addressing the following issues: (1) the relationship between frequency and stability by means of corpus studies of at least a few of the Mayan languages; (2) the use of innovative polysemies for subgrouping, and for identifying contact between languages and subgroups; (3) the validity of proposed cross-linguistic tendencies of polysemy and shift (Stark 1969; Stross 1976; Matisoff 1978; Andersen 1978; Wilkins 1996); and (4) the utility of overtly marked expressions to assess directionality of (secondary) polysemies and shifts (Witkowski & Brown 1985; Urban 2011).

Finally, given the utility of the PMED by Kaufman with Justeson (2003), it is worth noting that there is another language family in Mesoamerica, besides Mayan, for which a comparably detailed, historical etymological database is available: Mixe-Zoquean. Specifically, Wichmann's (1995) comparative phonology and lexicon of Mixe-Zoquean would lend itself to this type of work. Consequently, applying and improving the methodology introduced in this paper to the anatomical domain in the Mixe-Zoquean family will also constitute a future priority.

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The following grammatical category abbreviations are employed in this paper

1/2/3	grammatical person
ABS	absolutive
ABSTR	abstractivizer (noun/adjective > abstract noun)
DISTR	distributive
ERG	ergative
INAM.POSS	inanimate possession
IVZR	intransitivizer
MPASS	mediopassive
PL	plural
PREP	preposition
PROCL	proclitic
SG	singular
UNPOSS	unpossession (absolute) marker of inalienable nouns

Appendix 1. Datasets from Tadmor, Haspelmath and Taylor (2010)

Table 1. Data from Tadmor, Haspelmath and Taylor (2010: 232–233, Table 3)

ID	Narrow field	No of meanings	Loanwords	Broader field
1	Religion and belief	26	41.2	Culture
2	Clothing and grooming	59	38.6	Culture
3	The house	47	37.2	Culture
4	Law	26	34.3	Culture
5	Social and political relations	36	31	Culture
6	Agriculture and vegetation	75	30	Culture
7	Food and drink	81	29.3	Culture

ID	Narrow field	No of meanings	Loanwords	Broader field
8	Warfare and hunting	40	27.9	Culture
9	Possession	46	27.1	Culture
10	Animals	116	25.5	Culture-free
11	Cognition	51	24.2	Culture-free
12	Basic actions and technology	78	23.8	Culture
13	Time	57	23.2	Culture
14	Speech and language	41	22.3	Culture
15	Quantity	39	20.5	Culture
16	Emotions and values	48	19.9	Culture
17	The physical world	75	19.8	Culture-free
18	Motion	82	17.3	Culture-free
19	Kinship	85	15	Culture
20	The body	159	14.2	Culture-free
21	Spatial relations	75	14	Culture-free
22	Sense perception	49	11	Culture-free

Table 2. Leipzig-Jakarta world list with added semantic fields (Tadmor, Haspelmath & Taylor 2010: 239–241, Table 7)

Rank	Word meaning	Semantic field	Borrowed score	Age score	Analyzability score	Representation score	Composite score
46	to bite	Actions	0.964	0.861	0.887	1.000	0.736
79	to blow	Actions	0.962	0.857	0.878	0.976	0.706
53	to burn (intr.)	Actions	0.951	0.860	0.889	1.000	0.727
70	to carry	Actions	0.919	0.838	0.953	0.976	0.717
11	to come	Actions	0.968	0.876	0.940	1.000	0.796
100	to crush/ grind	Actions	0.919	0.845	0.886	1.000	0.688
87	to cry/ weep	Actions	0.871	0.871	0.921	1.000	0.698
25	to do/ make	Actions	0.947	0.877	0.914	1.000	0.759
42	to drink	Actions	0.904	0.877	0.934	1.000	0.741
75	to eat	Actions	0.920	0.840	0.925	1.000	0.714
81	to fall	Actions	0.946	0.825	0.903	1.000	0.704

Rank	Word meaning	Semantic field	Borrowed score	Age score	Analyzability score	Representation score	Composite score
53	to give	Actions	0.913	0.878	0.907	1.000	0.727
3	to go	Actions	0.963	0.887	0.974	1.000	0.832
61	to hear	Actions	0.953	0.848	0.895	1.000	0.723
67	to hide	Actions	0.928	0.847	0.913	1.000	0.718
36	to hit/beat	Actions	0.955	0.827	0.947	1.000	0.748
58	to know	Actions	0.933	0.856	0.908	1.000	0.725
61	to laugh	Actions	0.942	0.844	0.910	1.000	0.723
81	to run	Actions	0.976	0.833	0.867	1.000	0.704
28	to say	Actions	0.972	0.837	0.928	1.000	0.755
89	to see	Actions	0.918	0.842	0.900	1.000	0.695
45	to stand	Actions	0.981	0.847	0.889	1.000	0.738
67	to suck	Actions	0.940	0.860	0.888	1.000	0.718
71	to take	Actions	0.900	0.898	0.887	1.000	0.716
88	to tie	Actions	0.879	0.836	0.948	1.000	0.697
19	arm/hand	Anatomy	0.881	0.903	0.966	1.000	0.768
46	back	Anatomy	0.918	0.868	0.924	1.000	0.736
7	blood	Anatomy	0.904	0.890	1.000	1.000	0.805
7	bone	Anatomy	0.918	0.904	0.971	1.000	0.805
12	breast	Anatomy	0.947	0.856	0.967	1.000	0.783
22	ear	Anatomy	0.896	0.888	0.961	1.000	0.764
83	eye	Anatomy	0.904	0.847	0.918	1.000	0.703
18	flesh/meat	Anatomy	0.877	0.892	0.986	1.000	0.771
31	hair	Anatomy	0.944	0.871	0.917	1.000	0.754
59	knee	Anatomy	0.911	0.862	0.922	1.000	0.724
64	leaf	Anatomy	0.897	0.823	0.977	1.000	0.721
37	leg/foot	Anatomy	0.856	0.897	0.972	1.000	0.747
66	liver	Anatomy	0.869	0.857	0.967	1.000	0.720
5	mouth	Anatomy	0.920	0.904	0.982	1.000	0.817
42	navel	Anatomy	0.878	0.860	0.982	1.000	0.741
23	neck	Anatomy	0.895	0.881	0.964	1.000	0.760
2	nose	Anatomy	0.973	0.906	0.980	1.000	0.864
67	skin/hide	Anatomy	0.889	0.875	0.924	1.000	0.718
76	thigh	Anatomy	0.906	0.856	0.918	1.000	0.712
6	tongue	Anatomy	0.934	0.908	0.954	1.000	0.808
28	tooth	Anatomy	0.882	0.877	0.975	1.000	0.755
52	egg	Anatomy	0.910	0.846	0.945	1.000	0.728
38	horn	Anatomy	0.840	0.898	0.987	1.000	0.745

Rank	Word meaning	Semantic field	Borrowed score	Age score	Analyzability score	Representation score	Composite score
9	root	Anatomy	0.944	0.869	0.973	1.000	0.798
84	tail	Anatomy	0.883	0.813	0.973	1.000	0.699
17	wing	Anatomy	0.884	0.904	0.968	1.000	0.773
80	wood	Anatomy	0.860	0.871	0.940	1.000	0.705
71	ant	Animal	0.865	0.850	0.975	1.000	0.716
91	bird	Animal	0.842	0.857	0.962	1.000	0.694
84	dog	Animal	0.838	0.869	0.960	1.000	0.699
38	fish	Animal	0.855	0.885	0.984	1.000	0.745
20	fly	Animal	0.948	0.858	0.942	1.000	0.766
15	louse	Animal	0.950	0.861	0.946	1.000	0.774
51	child (kin term)	Animal	0.929	0.866	0.930	0.976	0.730
26	house	Cultural	0.893	0.876	0.969	1.000	0.758
15	name	Cultural	0.915	0.886	0.955	1.000	0.774
91	rope	Cultural	0.848	0.824	0.993	1.000	0.694
14	1sg pronoun	Grammatical	0.970	0.875	0.936	0.976	0.776
9	2sg pronoun	Grammatical	0.958	0.893	0.933	1.000	0.798
34	3sg pronoun	Grammatical	1.000	0.893	0.955	0.878	0.749
97	in	Grammatical	0.948	0.856	0.943	0.902	0.691
56	not	Grammatical	0.965	0.880	0.974	0.878	0.726
32	one	Grammatical	0.870	0.893	0.969	1.000	0.753
38	this	Grammatical	1.000	0.851	0.897	0.976	0.745
50	what?	Grammatical	0.971	0.804	0.939	1.000	0.732
34	who?	Grammatical	0.968	0.838	0.924	1.000	0.749
41	yesterday	Grammatical	0.958	0.843	0.922	1.000	0.744
84	ash	Natural phenomena	0.853	0.891	0.921	1.000	0.699
1	fire	Natural phenomena	0.965	0.939	0.995	1.000	0.901
20	night	Natural phenomena	0.931	0.880	0.934	1.000	0.766
13	rain	Natural phenomena	0.916	0.898	0.950	1.000	0.782
91	salt	Natural phenomena	0.848	0.838	0.976	1.000	0.694

Rank	Word meaning	Semantic field	Borrowed score	Age score	Analyzability score	Representation score	Composite score
59	sand	Natural phenomena	0.901	0.866	0.928	1.000	0.724
91	shade/ shadow	Natural phenomena	0.887	0.840	0.931	1.000	0.694
49	smoke	Natural phenomena	0.916	0.863	0.929	1.000	0.734
63	soil	Natural phenomena	0.900	0.883	0.954	0.951	0.722
97	star	Natural phenomena	0.830	0.859	0.970	1.000	0.691
27	stone/rock	Natural phenomena	0.895	0.882	0.958	1.000	0.756
4	water	Natural phenomena	0.909	0.926	0.987	1.000	0.831
48	wind	Natural phenomena	0.828	0.900	0.987	1.000	0.736
91	small	Properties	0.909	0.790	0.966	1.000	0.694
89	sweet	Properties	0.914	0.857	0.887	1.000	0.695
76	thick	Properties	0.950	0.827	0.906	1.000	0.712
32	big	Properties	0.889	0.864	0.980	1.000	0.753
28	bitter	Properties	0.975	0.872	0.889	1.000	0.755
42	black	Properties	0.951	0.866	0.899	1.000	0.741
23	far	Properties	0.944	0.850	0.948	1.000	0.760
56	good	Properties	0.893	0.860	0.945	1.000	0.726
99	hard	Properties	0.918	0.833	0.903	1.000	0.690
71	heavy	Properties	0.911	0.874	0.901	1.000	0.716
78	long	Properties	0.956	0.824	0.898	1.000	0.707
53	new	Properties	0.920	0.860	0.920	1.000	0.727
74	old	Properties	0.896	0.867	0.920	1.000	0.715
64	red	Properties	0.926	0.864	0.900	1.000	0.721
96	wide	Properties	0.955	0.819	0.885	1.000	0.692

Appendix 2. Mayan dataset of 50 anatomical etyma sorted for Mayan

No.	Etyma	Stage	Gloss	Epigraphic Mayan	S3	S4	Polysemies
1	***b'aaq**	pM	bone	**b'a-ki, b'a-ke**	2.22	2.22	6

Appendix 2. *(continued)*

No.	Etyma	Stage	Gloss	Epigraphic Mayan	S3	S4	Polysemies
2	***b'ah**	**pCM**	head; first; reflexive; top	**b'ah, b'a-hi**	0.84	0.84	6
3	***hat'is ~ *hat'iʃ ~ *hatʃ'iʃ**	pM	sneeze	–	1.78	1.78	1
4	***Haty (weak h)**	pM	eye, face; fruit	**7u, 7UT/HUT/WUT**	2.28	2.43	10
5	***k'u.. / *k'uʔx**	pCM	belly/stomach		0.97	1.19	6
6	***kiis ~ *tsiis ~ *tiis**	pM	fart	**ki-si-ni, ti-si**	1.81	1.81	3
7	***kik'**	pM	blood	**CH'ICH'/K'IK'**	2.66	2.66	3
8	***kooh**	pM	(molar) tooth	**cho**	0.63	1.00	6
9	***matsaab'**	pM	eyelash(es)	–	1.06	1.74	2
10	***meʔts**	LpM	eyebrow	–	0.38	0.6	4
11	***nuuq'**	pM	neck	–	0.81	1.37	3
12	***ŋeeh**	pM	tail	**ne/NEH**	3.00	3.00	1
13	***ŋiiʔ ~ *ŋuuʔ**	pM	nose; tip/point	**ni-7i, ni**	1.22	1.22	6
14	***paam**	pM	belly	–	0.66	1.91	4
15	***palaaŋ**	pM	forehead	–	1.09	1.75	2
16	***q'ab'**	pM	hand, arm	**K'AB', k'a[b'a]-si, k'a-b'a-la**	2.50	2.50	5
17	***q'an, *q'an-al**	pM	fat	–	0.75	1.6	1
18	***q'oʔts**	pCM	cheek	–	0.47	0.75	1
19	***qeeb'**	pM	belch	–	2.06	2.06	1
20	***sahm ~ *sihm**	pM	mucus	–	1.25	1.25	5
21	***ʃaʔ ~ *ʃaʔw ~ *ʃab'**	pM	vomit	–	1.69	2.45	1

Appendix 2. *(continued)*

No.	Etyma	Stage	Gloss	Epigraphic Mayan	S3	S4	Polysemies
22	***ʃiik’**	pM	wing	–	1.81	1.93	2
23	***ʃikin**	LpM	ear	Possibly **chi-ki-in**	2.56	2.73	2
24	***ʃiʔ**	pM	hair; hair of head	–	0.50	1.23	6
25	***ʃuhk**	pM	corner; side	–	0.63	0.8	4
26	***toʔp**	pCM	arse	–	0.59	1.12	3
27	***ts’eet**	pCM	left hand	–	0.38	0.8	1
28	***ts’uhuum**	pCM	skin, hide	–	1.38	1.69	10
29	***tsaaʔ**	pM	excrement	–	1.13	1.29	3
30	***tsel ~ *tsal**	LpM	sideways	–	1.06	1.42	4
31	***tsuk**	pCM	facial hair, corn silk	–	0.59	1.36	4
32	***tʃihn**	pM	brains	–	0.31	0.67	2
33	***tʃu(u)ʔ**	LpM	women’s breast	–	0.81	1.24	3
34	***tʃuq’ub’**	LpM	hiccup	–	0.97	1.03	2
35	***tyiiʔ**	LpM	mouth	**TI7, TI7-7i, TI7-si**	1.97	2.10	7
36	***tyuhb’**	LpM	spit(tle)	–	2.34	2.34	1
37	***wiʔ**	LpM	head; hair (of head)	**wi**	0.69	0.73	10
38	***xool-oom**	LpM	head	**JOL-ma**	1.53	1.63	8
39	***ʔaab’**	pCM	urine	–	0.28	0.60	1
40	***ʔaaq’/*ʔaaʔq’**	LpM	tongue	**?ya**	2.81	3.00	1
41	***ʔaaty**	pM	penis	**7AT, 7AT-ti, 7AT-ta**	1.19	1.68	9
42	***ʔaaʔ**	pCM	thigh	–	0.94	1.36	2
43	***ʔaqan**	pM	foot, leg	**?7AKAN**	1.25	1.43	7
44	***ʔeeh**	LpM	tooth; edge	**ye**	2.03	2.17	3

Appendix 2. *(continued)*

No.	Etyma	Stage	Gloss	Epigraphic Mayan	S3	S4	Polysemies
45	***ʔiim**	pM	women's breast/bosom	–	1.00	1.88	2
46	***ʔiit**	LpM	arse	–	0.53	0.88	6
47	***ʔiSk'aq**	pM	nail/claw/ hoof	**yi-ch'a-ki**	2.72	2.72	3
48	***ʔism**	pM	non-head hair	**ʔ7i-si-ma**	1.06	1.06	10
49	***ʔooq**	LpM	foot, leg	**7o-ke, yo-ki, yo-ko**	1.22	1.30	5
50	***ʔuuk'aaʔ**	pM	horn	–	1.50	2.18	1

Appendix 3. Mayan dataset of 50 anatomical etyma sorted for English glosses

No.	Etyma	Stage	Gloss
8	***kooh**	pM	(molar) tooth
26	***toʔp**	pCM	arse
46	***ʔiit**	LpM	arse
19	***qeeb'**	pM	belch
14	***paam**	pM	belly
5	***k'u.. / *k'uʔx**	pCM	belly/stomach
7	***kik'**	pM	blood
1	***b'aaq**	pM	bone
32	***tʃihn**	pM	brains
18	***q'oʔts**	pCM	cheek
25	***ʃuhk**	pM	corner; side
23	***ʃikin**	LpM	ear
29	***tsaaʔ**	pM	excrement
4	***Haty (weak h)**	pM	eye, face; fruit
10	***meʔts**	LpM	eyebrow

Appendix 3. *(continued)*

No.	Etyma	Stage	Gloss
9	***matsaab’**	pM	eyelash(es)
31	***tsuk**	pCM	facial hair, corn silk
6	***kiis ~ *tsiis ~ *tiis**	pM	fart
17	***q’an, *q’an-al**	pM	fat
43	***ʔaqan**	pM	foot, leg
49	***ʔooq**	LpM	foot, leg
15	***palaaŋ**	pM	forehead
24	***ʃiʔ**	pM	hair; hair of head
16	***q’ab’**	pM	hand, arm
38	***xool-oom**	LpM	head
2	***b’ah**	**pCM**	head; first; reflexive; top
37	***wiʔ**	LpM	head; hair (of head)
34	***tʃuq’ub’**	LpM	hiccup
50	***ʔuuk’aaʔ**	pM	horn
27	***ts’eet**	pCM	left hand
35	***tyiiʔ**	LpM	mouth
20	***sahm ~ *sihm**	pM	mucus
47	***ʔiSk’aq**	pM	nail/claw/hoof
11	***nuuq’**	pM	neck
48	***ʔism**	pM	non-head hair
13	***ŋiiʔ ~ *ŋuuʔ**	pM	nose; tip/point
41	***ʔaaty**	pM	penis
30	***tsel ~ *tsal**	LpM	sideways
28	***ts’uhuum**	pCM	skin, hide
3	***hat’is ~ *hat’iʃ ~ *hatʃ’iʃ**	pM	sneeze
36	***tyuhb’**	LpM	spit(tle)
12	***ŋeeh**	pM	tail
42	***ʔaaʔ**	pCM	thigh
40	***ʔaaq’/*ʔaaʔq’**	LpM	tongue
44	***ʔeeh**	LpM	tooth; edge

Appendix 3. *(continued)*

No.	Etyma	Stage	Gloss
39	***ʔaab'**	pCM	urine
21	***ʃaʔ ~ *ʃaʔw ~ *ʃab'**	pM	vomit
22	***ʃiik'**	pM	wing
33	***tʃu(u)ʔ**	LpM	women's breast
45	***ʔiim**	pM	women's breast/bosom

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