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Graphemic Variation in Morphosyntactic Context: The Syllable u in Classic Maya Hieroglyphic Writing

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Abstract

Throughout the long history of Classic Maya hieroglyphs, a logosyllabic writing system used from the late first millennium BCE through the mid-second millennium CE in southern Mesoamerica, the most commonly recorded phonetic value was the syllable **u** (/ʔu/). With over a dozen different **u** hieroglyphs, Classic Maya scribes had more options for recording /ʔu/ than any other syllable or logograph. Cognitive approaches to writing systems typically attribute graphemic variation (i.e., alternation between signs with equivalent linguistic value) to semantic differences like animacy or to non-linguistic factors like identity. Distribution of Classic Maya **u** hieroglyphs, however, suggests that morphosyntactic context influenced which grapheme scribes wrote and when. This case suggests that scribal knowledge of Classic Maya hieroglyphs included ideas about writing's relationship to language. It also highlights the cognitive relevance of morphosyntax for a writing system's users as they differentiate among graphic signs with identical linguistic denotation.

Keywords: Classic Maya; Hieroglyphic writing; Graphemic variation; Morphosyntax; Orthography; Scribal practice

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1. Introduction

Linguistic ideals mandate that a writing system should have a perfect one-to-one correspondence between phonetic and graphic units; in other words, each phoneme, or smallest meaningful unit of sound, should correspond to one and only one written sign, and vice versa (Defrancis, 1996; cf. Meletis, 2019). In practice, writing systems have never achieved perfect one-to-one sign–sound correspondence in their orthography or norms about how and when to use the signs within a writing system (Meletis & Dürscheid, 2022, p. 171). Those that have come closest to the linguistic ideal have only done so through top-down orthographic reform (Defrancis, 1996, pp. 367–369). In the absence of centralized intervention, premodern scribes sometimes made individual or collective efforts to regularize writing conventions on the ground. For example, the orthography in the early eighth-century Japanese manuscript known as the *Kojiki* 古事記 systematizes sign–sound correspondences such that one character has only one reading (Inukai, 1996, as cited in Lurie, 2011, pp. 228–229). In this respect, the *Kojiki* was unusual for its time; contemporaneous texts indicate that other Japanese scribes tended to use a given character across various semantic contexts and to choose among several distinct logographs to communicate a given meaning (Inukai, 1996, as cited in Lurie, 2011, pp. 228–229).

One inherent challenge to the pursuit of the one-to-one ideal is that the model does not account for other phonetic factors like suprasegmentals that derive their significance from relative rather than absolute values (Defrancis, 1996, p. 366). Other linguistic factors like semantics may influence graphemic variation, too. For example, the increasing frequency of written references to humans and other animate beings seems to have driven the rise of "sentence-internal capitalization" in German and English orthography during the 16th and 17th centuries (Barteld, Hartmann, & Szczepaniak, 2016; Nowak & Hartmann, 2024). Another challenge is language change, which proceeds more quickly and disjointedly than adaptations in the written language (Defrancis, 1996, p. 366). Isolation of local temple communities in Roman-period Egypt, for instance, appears to have accelerated orthographic variation among scribal traditions (Ryholt, 2017, p. 178). Writing systems have always featured a certain degree of graphemic variation or alternation between signs with the same linguistic value with equivalent linguistic value.

Graphemic variation affords writers more flexibility in composition. It also creates ambiguity for readers facing signs or passages with multiple possible linguistic interpretations. Over the course of human history, writers have developed a range of strategies for adapting to the cognitive demands presented by reading and writing in a context of graphemic variation. Many strategies have entailed streamlining graphemic selection and interpretation. Hittite cuneiform scribes in Anatolia and northern Syria during the mid-second millennium BCE had at their disposal both syllabic signs and so-called Sumerograms or logographs inherited from Sumerian (Kudrinski & Yakubovich, 2016; Laroche, 1978; Weeden, 2011). But they did not necessarily use the signs interchangeably. In the case of verbs, for instance, they initially limited Sumerograms to nominal forms derived from verbs and almost always wrote other verbal forms with syllabic signs only (Busse, 2013, pp. 89–90). Writers in Shang-dynasty China, in turn, added strokes to create new characters from polyvalent or homophonic signs,

increasing the sign inventory to make reading more transparent (Dematté, 2022, pp. 329–330). Similarly, the Egyptian scribe Amennakhte, who was active in Deir el-Medina in the mid-12th century BCE, regularized his hieroglyphic spellings of singular and plural nominal morphology, whereas texts from his contemporaries manifest a range of orthographic variation (Polis, 2017, pp. 103–104).

In light of modern studies of literacy acquisition, these ancient developments appear to reflect readers and writers' ability to process orthographic variation more quickly when it patterns with morphosyntactic or morphophonological features. Dutch children learning to spell regular past tense verb forms choose between the past-tense suffixes *-de(n)* or *-te(n)*, allographs whose distribution in standard orthography is graphotactically determined, based on visual recognition and frequency, in addition to morphophonological understanding of each form's correct pronunciation (de Bree, van der Ven, & van der Maas, 2017). Other studies have found that the German system of regular noun capitalization facilitates quicker processing of semantic and syntactic roles by drawing attention to nominal phrases (Bock, Augst, & Wegner, 1985; Bock, Hagenschneider, & Schweer, 1989; see also Gfroerer, Günther, & Bock, 1989). Chinese homographs, characters with several semantically and sometimes phonetically distinct readings that vary according to context, have been found to prime word processing more effectively than characters that are homophonic but not homographic (Wu, Tsang, Wong, & Chen, 2017; Zhou, Marslen-Wilson, Taft, & Shu, 1999). Streamlined or regularized sign–sound correspondences within a writing system thus lightens the processing load for its users.

The present article examines a set of Classic Maya (250–900 CE) hieroglyphs whose distribution suggests that scribes mapped graphemic variation onto morphosyntactic patterns. The graphemes in question all denote the Classic Mayan syllable /ʔu/, which epigraphers transcribe as **u** or, less commonly, **ʻu** when analyzing hieroglyphic inscriptions (see Fox & Justeson, 1984a; Stuart, 1988). Scribes introduced more than a dozen **u** hieroglyphs over the course of Classic Maya history. The signs were used in syllabic spellings of lexemes, most often the intransitive stem *uht* "happen, occur" (Stuart, 1990). More frequently, they denoted morphological information and specifically the preconsonantal form (*u-*) of the third-person singular ergative pronoun (Stuart, 1990, pp. 219–220; Thompson, 1950, p. 188). In theory, Classic Maya scribes could use all **u** signs interchangeably because of their equivalent phonetic value. In the case of such free variation, one would expect the relative frequency of **u** graphemes to remain somewhat consistent across linguistic environments. Close examination of graphemic distribution in written texts, however, indicates that scribal preferences for one grapheme over another were conditioned at least in part by morphosyntactic context.

2. Classic Maya writing and the syllable u

Maya hieroglyphs were used continuously from at least the fourth century BCE through the 16th century CE across a region spanning what is now southern Mexico, Guatemala, Belize, western Honduras, and western El Salvador (Fig. 1). The majority of hieroglyphic texts date to the Late Classic period (600–820), an era of cultural florescence that proceeded the col-

Fig. 1. Map of the Maya lowlands indicating archaeological sites mentioned in this article. (Compiled by the author in ArcGISPro. World Imagery (WGS84) basemap copyright 2023 Esri, Maxar, Earthstar Geographics, and the GIS User Community.)

lapse of divine kingship and abandonment of many lowland sites during the Terminal Classic period (820–900; see Coe & Houston, 2022; Houston & Martin, 2016). Typologically, the writing system is logo-syllabic. Almost all hieroglyphs fall into one of two classes: logographs denoting a consonant–vowel sequence or cluster—usually CVC or, less commonly, CVCVC or CVCCVC—plus associated semantic meaning, and hieroglyphs denoting a syllable (CV) with no semantic content (Law & Stuart, 2017, p. 154; see Justeson & Campbell, 1984).

A few signs are polyvalent and have a logographic and a syllabic value so that the reader must deduce based on context which reading applies on a given occasion (Fox & Justeson, 1984b). Lexemes are more likely to be written with a logograph, whereas morphological information is denoted almost exclusively with syllabic hieroglyphs. Some epigraphers have

proposed classifying the latter signs as "morphosyllables," an in-between class of syllabic signs that function as logographs in specific morphosyntactic contexts (Houston, Robertson, & Stuart, 2001, pp. 14–23). However, the proposal has not been widely adopted (Gronemeyer, 2011; Lacadena García-Gallo & Wichmann, 2019, pp. 187–189; Mora-Marín, 2010).

Graphically speaking, the hieroglyph was the smallest basic unit within a Classic Maya text. Hieroglyphs were arranged into so-called glyph blocks, roughly square collocations that could contain anywhere from one to more than a dozen individual hieroglyphs and often, but not always, corresponded to a lexical unit or phrase (Stone & Zender, 2011, p. 17; see Prager & Gronemeyer, 2018). A text consisted of at least one and up to more than 100 glyph blocks, and although scribes often experimented with layout, glyph blocks were most commonly arranged and read in double-column format.

The hieroglyphic script encoded a historical language now referred to as Classic Mayan, whose closest modern-day linguistic relative is widely considered to be the endangered language Ch'orti' (Houston et al., 2001; Houston, Robertson, & Stuart, 2000). As something of an elite *lingua franca*, Classic Mayan was written in inscriptions across the lowlands for centuries but probably was not widely spoken for much of that time. In some texts, epigraphers have identified elements of other, local languages, especially from the Tzeltalan and Yucatecan branches of the Mayan language family, which suggest that many scribes were operating in a diglossic context (Hruby & Child, 2004; Josserand & Hopkins, 2002; Lacadena García-Gallo, 2000; Wald, 2004).

A typological overview of Classic Mayan is beyond the scope of this article (see recent summary in Law & Stuart, 2017). The structural feature most central to the following discussion is ergativity. Like other Mayan languages, Classic Mayan featured ergative-absolutive morphosyntactic alignment, with one set of ergative pronouns (commonly referred to in Mayan linguistics as "Set A") for the agent of transitive verbs and another set of absolutive pronouns ("Set B") for the object of transitive verbs, the subject of intransitive verbs, and non-verbal predicates (Law & Stuart, 2017, pp. 143, tab. 6.3; see Law, Robertson, & Houston, 2006). In Classic Mayan, the ergative or "Set A" pronouns were also used as possessive pronouns for nominal phrases, a feature shared with other Mayan languages (Law & Stuart, 2017, p. 144). Hieroglyphic texts were written predominately in the third person, and plural forms were frequently underrepresented as singular in nominal and verbal morphology (Law & Stuart, 2017, pp. 143–145; cf. Law, 2014, pp. 74–81, 97–101). Consequently, the best attested Classic Mayan pronoun by far is the third-person singular ergative form, realized as *y-* in the prevocalic position and as *u-* in the preconsonantal position. The present case study concerns hieroglyphs that were used in part to represent the latter allomorph.

Throughout the writing system's history, Classic Maya orthography was defined by scribal preferences or tendencies rather than by authoritative rules or standardization. Although Meletis and Dürscheid (2022, pp. 172,173) apply the label of "unstandardised writing systems…without an official orthography" primarily to "relatively young" systems, they acknowledge that even centrally established orthographies tend to have their roots in "user-based conventions" that were shaped by sociohistorical context and decentralized dissemination of norms. The latter scenario, which Jan Goossens (1994, p. 84) has described as "spontaneous standardization," characterized Maya writing for nearly two millennia. The hieroglyphs were

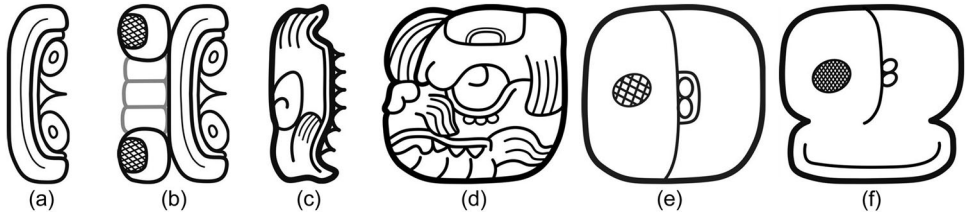

Fig. 2. Common Classic Maya hieroglyphs with the syllabic value **u**: (a) T0001br, (b) T0001bh, (c) T0204bt, (d) T0204bv, (e) T0513bt, and (f) T0513bv. Drawings by Christian Prager.

used across dozens of polities that shared a cultural and linguistic background but had no common political affiliation (Martin, 2020; Martin & Grube, 2000). Despite ample evidence of Classic Maya scribal and artistic exchange, there is no indication that any one community exercised normative influence on writing practices across the region (Matsumoto, 2021). The patterns identified in this study thus reflect shared practices that arose through generations of knowledge transmission among scribes as opposed to conventions enforced by a centralized authority.

3. Hieroglyphs for the syllable u: T0001br-bh, T0204bt, T0204bv, T0513bt-bv

The most frequently written syllable in the Classic Maya corpus, **u** is expressed in the hieroglyphic script by over two dozen distinct graphemes, far more than any other linguistic value. The first and only systematic study to date of the syllable's many hieroglyphic forms is an unpublished term paper by Brewer (1998), who observed meaningful patterns in distribution between communities and in the number of variants used at any given political center. He argued that the distinctive distribution of **u** graphemes arose from interaction between individual practices and "consensus or unity among the scribes" about which variants to deploy in which contexts (Brewer, 1998, p. 10). Although Brewer (1998) and Stuart (1990) before him allude to preferences for **u** signs based on linguistic or textual context, that aspect of orthography was not the focus of their respective studies at the time.

Here, I examine the distribution of four of the most common **u** hieroglyphs, which are designated as T0001bh-br, T0204bt, T0513bt-bv, and T0204bv (Fig. 2a–f), respectively, in the classification established by Thompson (1962) that the Textdatenbank und Wörterbuch des Klassischen Maya (TWKM) project at the University of Bonn, Germany, is currently updating (Prager & Gronemeyer, 2018).[1] All four graphemes are attested by the early sixth century, whereafter they rapidly became associated with specific morphosyntactic contexts of use (Matsumoto, 2021, pp. 413–418). Based on distributional analysis, I argue that morphosyntactic concerns influenced which **u** grapheme scribes wrote and when. Scribal knowledge of the Classic Maya hieroglyphic script thus included ideas about writing's relationship to language, including morphosyntax's influence on selection among graphic signs with identical linguistic denotation.

Table 1
Distribution of **u** syllabic hieroglyphs across all contexts in texts from 19 Classic Maya dynastic centers. Percentage totals may deviate slightly from 100% due to rounding

	T0001bh-br (% Total)	T0204bt (% Total)	T0204bv (% Total)	T0513bt-bv (% Total)	Other **u** (% Total)	Total **u** hieroglyphs
Calakmul	54 (59.3)	8 (8.8)	6 (6.6)	11 (12.1)	12 (13.2)	91
Cancuen	3 (6.0)	2 (4.0)	2 (4.0)	14 (28.0)	29 (58.0)	50
Caracol	88 (63.3)	13 (9.4)	1 (0.7)	17 (12.2)	20 (14.4)	139
Chichen Itza	58 (43.0)	4 (3.0)	1 (0.7)	10 (7.4)	62 (45.9)	135
Coba	49 (76.6)	3 (4.7)	0	5 (7.8)	7 (10.9)	64
Copan	186 (40.1)	37 (8.0)	35 (7.5)	37 (8.0)	169 (36.4)	464
Dos Pilas/Aguateca	46 (24.1)	8 (4.2)	23 (12.0)	43 (22.5)	71 (37.2)	191
Itzan	23 (41.1)	1 (1.8)	2 (3.6)	5 (8.9)	25 (44.6)	56
La Corona	54 (37.5)	22 (15.3)	24 (16.7)	29 (20.1)	15 (10.4)	144
Machaquila	15 (27.3)	7 (12.7)	1 (1.8)	11 (20.0)	21 (38.2)	55
Naranjo	151 (77.0)	5 (2.6)	3 (1.5)	18 (9.2)	19 (9.7)	196
Palenque	88 (18.4)	86 (18.0)	45 (9.4)	38 (7.9)	221 (46.2)	478
Piedras Negras	140 (54.7)	20 (7.8)	7 (2.7)	39 (15.2)	50 (19.5)	256
Pomona	7 (13.5)	13 (25.0)	9 (17.3)	8 (15.4)	15 (28.8)	52
Pusilha	38 (71.7)	2 (3.8)	0	1 (1.9)	12 (22.6)	53
Quirigua	100 (41.7)	23 (9.6)	19 (7.9)	37 (15.4)	61 (25.4)	240
Tikal	126 (68.9)	32 (17.5)	5 (2.7)	6 (3.3)	14 (7.7)	183
Tonina	126 (59.7)	9 (4.3)	7 (3.3)	29 (13.7)	40 (19.0)	211
Yaxchilan	221 (57.0)	15 (3.9)	17 (4.4)	33 (8.5)	102 (26.3)	388

The present analysis is based on more than 3400 total occurrences of the four graphemes in texts from 19 dynastic centers, which were selected among more than 75 archaeological sites with Classic Maya inscriptions because of their relatively large samples of **u** hieroglyphs (total $n \geq 50$; Fig. 1; Table 1). Data were compiled while reading through each inscription and entered into a Filemaker database for curation.[2] Almost all inscriptions analyzed were archaeologically excavated; most were carved on monumental stone, although a small number were molded, carved, incised, or painted in other media such as stone, stucco, bone, or ceramic. The few unprovenanced texts included in the study are ones for which specialists have reconstructed a feasible site of origin based on epigraphic and iconographic comparison.

The most frequent **u** grapheme and the single-most common hieroglyph in the Classic Maya corpus at large is T0001bh and especially its simpler allograph T0001br (Fig. 2a,b). The graphic origins of T0001bh-br are unclear, although some have proposed that it derives from representations of a "bead" or "necklace" (*uuh* in Classic Mayan; Bricker, 1986, p. 52; Justeson, 1989, p. 32). In the following discussion, I refer to the grapheme as "bracket-**u**" for easier reference. The second-most common of the four **u** hieroglyphs under discussion, T0204bt (hereafter "head-**u**"), iconically represents the forehead and eye of a fish (Thompson, 2001[1944], pp. 128–134). Its full form can be seen in the hieroglyph T0204bv (hereafter

"fish-**u**"; Fig. 2c,f; Stone & Zender, 2011, p. 191; Thompson, 2001[1944], pp. 128–134; see also Houston et al., 2000, p. 328).

Although updated classifications identify them as allographs of a common grapheme (Prager & Gronemeyer, 2018, Abb. 11), I treat head-**u** and fish-**u** as separate graphemes because of their distinct formal properties, which have no bearing on the signs' phonetic value but may affect the morphosyntactic contexts in each sign tends to appear. In particular, the hieroglyphs' disparate shapes—head-**u** is long and narrow, while fish-**u** is thick and rounded—mean that they tend to occupy different positions within a glyph block. In particular, head-**u** often appears on the edges of a glyph block, whereas fish-**u** is usually at the center. For the same reason, I maintain the TWKM classification of T0513bt and T0513bv as allographs of one grapheme, hereafter "jar-**u**" due to T0513bv's resemblance to an upturned vessel (Fig. 2e,f; Fox & Justeson, 1984b, pp. 73–74). Unlike in the case of head-**u** and fish-**u**, the formal differences between the forms of jar-**u** are relatively minor and have no significant impact on their position within a glyph block. In addition, occurrences of T0513bv, which is by far the less common of allograph of jar-**u**, cluster in texts dated prior to the sixth century (Matsumoto, 2021, pp. 415–417). In other words, alternation between the allographs may be largely a function of chronology.

4. Morphosyntactic distribution of u hieroglyphs in Classic Maya texts

Despite different historical trajectories of development and transmission, the distribution of bracket-**u**, head-**u**, fish-**u**, and jar-**u** demonstrates that Early Classic scribes were already associating the graphemes with particular morphosyntactic contexts (Matsumoto, 2021, pp. 418–424). The fact that the patterns stabilized in the Late Classic era suggests that scribal knowledge about the four graphemes' morphosyntactic associations accumulated and disseminated across the lowlands through ongoing, multigenerational transmission.

4.1. Ergative third-person singular pronoun u-

With the sole exception of the allograph T0513bv (see below), the four **u** graphemes' earliest dated examples all occur as the third-person singular ergative pronoun *u-* in a possessive construction (Matsumoto, 2021, p. 418). For bracket-**u** and head-**u**, the possessive pronoun remained the primary context of use throughout the Classic period (Fig. 3a-b). Among 310 occurrences of head-**u** from the 19 dynastic centers (Table 1), almost all are ergative pronouns, with 80.6% ($n = 250$) occurring in a possessive construction and 13.5% ($n = 42$) marking the subject of a transitive verb (Figs. 3b,f and 4a,b; Table 2). Nonetheless, in the 19 centers' combined hieroglyphic corpus, head-**u** does not account for a significantly different proportion of the ergative pronoun *u-* relative to its representation among **u** hieroglyphs across all contexts, according to a chi-square test of independence ($\chi^2 = 0.66954$, $df = 1$, $p = .413$; Fig. 4c).[3]

More telling is the frequency with which bracket-**u** denotes the third-person singular ergative pronoun, even when considering the grapheme's predominance among **u** hieroglyphs generally (Figs. 3a,e and 4c). It accounts for an average of 46.4% **u** syllabic signs at the 19

Table 2
Distribution of **u** syllabic hieroglyphs as the third-person singular ergative pronoun *u-* in texts from 19 Classic Maya dynastic centers, separated by morphosyntactic context. Percentage totals may deviate slightly from 100% due to rounding

		T0001bh-br (% Total)		T0204bt (% Total)		T0204bv (% Total)		T0513bt-bv (% Total)		Other **u** (% Total)		Total *u-* Ergative Pronouns	
		By Context	Sum	By context	Sum	By context	Sum	By context	Sum	By context	Sum	By context	Sum
Calakmul	Transitive subject	3 (60.0)	42 (65.6)	0	8 (12.5)	0	2 (3.1)	0	0[b]	2 (40.0)	12 (18.8)	5	64
	Possessive	39 (66.1)		8 (13.6)		2 (3.4)		0[b]		10 (16.9)		59	
Cancuen	Transitive subject	1 (9.1)	2 (6.3)	0	1 (3.1)	0	0	0	0[a]	10 (90.1)	29 (90.6)	11	33
	Possessive	1 (4.8)		1 (4.8)		0		0[b]		19 (90.5)		21	
Caracol	Transitive subject	22 (66.7)	75 (71.4)	5 (15.2)	13 (12.4)	1 (3.0)	1 (1.0)	0[b]	0[a]	5 (15.2)	16 (15.2)	33	105
	Possessive	53 (73.6)		8 (11.1)		0		0[a]		11 (15.3)		72	
Chichen Itza	Transitive subject	2 (28.6)	39 (35.1)	0	4 (3.6)	1 (14.3)	1 (0.9)	1 (14.3)	9 (8.1)	3 (42.9)	58 (52.3)	7	111
	Possessive	37 (35.6)		4 (3.8)		0		8 (7.7)		55 (52.9)		104	
Coba	Transitive subject	16 (94.1)	39 (81.3)	1 (5.9)	3 (6.3)	0	0	0	0	0	6 (12.5)	17	48
	Possessive	23 (74.2)		2 (6.5)		0		0		6 (19.4)		31	
Copan	Transitive subject	20 (26.7)[a]	160 (45.6)	3 (4.0)	34 (9.7)	3 (4.0)	9 (2.6)[a]	1 (1.3)	11 (3.1)[b]	48 (64.0)	137 (39.0)	75	351
	Possessive	140 (50.7)[a]		31 (11.2)		6 (2.2)[a]		10 (3.6)[a]		89 (32.2)		276	
Dos Pilas/Aguateca	Transitive subject	14 (43.8)[a]	43 (35.8)[a]	3 (9.4)	8 (6.7)	0	1 (0.8)[a]	1 (3.1)[a]	1 (0.8)[a]	14 (43.8)	67 (55.8)	32	120
	Possessive	29 (33.0)		5 (5.7)		1 (1.1)[a]		0[a]		53 (60.2)		88	
Itzan	Transitive subject	1 (50.0)	22 (52.4)	0	0	0	0	0	0	1 (50.0)	20 (47.6)	2	42
	Possessive	21 (52.5)		0		0		0		19 (47.5)		40	
La Corona	Transitive subject	12 (57.1)[a]	47 (51.6)[a]	3 (14.3)	21 (23.1)	1 (4.8)	7 (7.7)	0[b]	0[a]	5 (23.8)	16 (17.6)	21	91
	Possessive	35 (50.0)		18 (25.7)		6 (8.6)		0[a]		11 (15.7)		70	
Machaquila	Transitive subject	1 (11.1)	14 (40.0)	2 (22.2)	7 (20.0)	0[b]	1 (2.9)	0	0[b]	6 (66.7)	16 (45.7)	9	35
	Possessive	13 (50.0)		5 (19.2)		1 (3.8)		0[b]		7 (26.9)		26	

(*Continued*)

Table 2
(Continued)

		T0001bh-br (% Total)		T0204bt (% Total)		T0204bv (% Total)		T0513bt-bv (% Total)		Other **u** (% Total)		Total *u*- Ergative Pronouns	
		By Context	Sum	By context	Sum	By context	Sum	By context	Sum	By context	Sum	By context	Sum
Naranjo	Transitive subject	29 (87.9)	146 (88.0)[a]	1 (3.0)	5 (3.0)	0	0	0	0[a]	3 (9.1)	15 (9.0)	33	166
	Possessive	117 (88.0)[a]		4 (3.0)		0		0[a]		12 (9.0)		133	
Palenque	Transitive subject	18 (18.8)	85 (21.6)	10 (10.4)	81 (20.6)	0[a]	17 (4.3)[a]	0[a]	3 (0.8)[a]	68 (70.8)	207 (52.7)	96	393
	Possessive	67 (22.6)		71 (23.9)		17 (5.7)		3 (1.0)[a]		139 (46.8)		297	
Piedras Negras	Transitive subject	25 (50.0)	127 (66.1)[a]	4 (8.0)	20 (10.4)	1 (2.0)	1 (0.5)	0[a]	0[a]	20 (40.0)	44 (22.9)	50	192
	Possessive	102 (71.8)[a]		16 (11.3)		0		0[a]		24 (16.9)		142	
Pomona	Transitive subject	1 (12.5)	6 (21.4)	3 (37.5)	12 (42.9)	0	0[b]	0	0[b]	4 (50.0)	10 (35.7)	8	28
	Possessive	5 (25.0)		9 (45.0)		0		0		6 (30.0)		20	
Pusilha	Transitive subject	8 (72.7)	31 (72.1)	0	2 (4.7)	0	0	0	0	3 (27.3)	10 (23.3)	11	43
	Possessive	23 (76.7)		2 (6.7)		0		0		7 (16.7)		30	
Quirigua	Transitive subject	30 (46.2)	88 (48.9)	4 (6.2)[a]	21 (11.7)	0[b]	2 (1.1)[a]	3 (4.6)[a]	5 (2.8)[a]	28 (43.1)	64 (35.6)	65	180
	Possessive	58 (50.4)		17 (14.8)		2 (1.7)[a]		2 (1.7)[a]		36 (31.3)		115	
Tikal	Transitive subject	26 (81.3)	123 (73.2)	3 (9.3)	31 (18.5)	0	3 (1.8)	0	0	3 (9.3)	11 (6.5)	32	168
	Possessive	97 (71.3)		28 (20.6)		3 (2.2)		0[b]		8 (5.9)		136	
Tonina	Transitive subject	20 (62.5)	112 (70.9)[a]	0	8 (5.1)	0	3 (1.9)	1 (3.1)	2 (1.3)[a]	11 (34.4)	33 (20.9)	32	158
	Possessive	92 (73.0)[a]		8 (6.3)		3 (2.4)		1 (0.8)[a]		22 (17.5)		126	
Yaxchilan	Transitive subject	18 (52.9)	205 (66.1)[a]	0	13 (4.2)	1 (2.9)	1 (0.3)[a]	0[b]	1 (0.3)[a]	15 (44.1)	90 (29.3)	34	310
	Possessive	187 (67.8)[a]		13 (4.7)		0[a]		1 (0.4)[a]		75 (27.2)		276	

[a]The hieroglyph's frequency in this context, compared to all other **u** hieroglyphs, differs from its frequency among **u** hieroglyphs across all contexts (see Table 1) at a statistically significant level ($df = 1, p > .05$), based on Pearson's chi-square test of independence. See Supporting Information for results of individual chi-square tests.

[b]The hieroglyph's frequency in this context, compared to all other **u** hieroglyphs, differs from its frequency among **u** hieroglyphs across all contexts (see Table 1) at a statistically significant level ($df = 1, p > .05$), based on Fisher's exact test. See Supporting Information for results of individual Fisher's exact tests.

Fig. 3. Examples of **u** hieroglyphs (outlined in yellow) as the third-person singular ergative pronoun *u-* in possessive constructions: (a) T0001br, (b) T0204bt, (c) T0204bv, (d) T0513bt; and as the subject of a transitive verb: (e) T0001br, f) T0204bt, g) T0204bv,[4] h) T0513bt. Photographs by the author (a–g), Carnegie Institution of Washington, Maya Image Archive (h); (a, c, e, g) courtesy of the Museo Nacional de Arqueología y Etnología de Guatemala, Guatemala City; (f) courtesy of the Museo de Sitio Pomona/INAH.

dynastic centers (Table 1). Still, bracket-**u** is overrepresented in pronominal contexts at a statistically significantly rate at six sites: Dos Pilas-Aguateca, La Corona, Naranjo, Piedras Negras, Tonina, and Yaxchilan (Table 2). At the paired dynastic centers Dos Pilas and Aguateca, for example, bracket-**u** represents just 24.1% of all **u** hieroglyphs but 35.8% of *u-* as an ergative pronoun ($\chi^2 = 4.422$, $df = 1$, $p = .035$). Likewise, the same sign represents 70.9% of *u-* in possessive and transitive verb phrases but just 59.7% of all **u** hieroglyphs at Tonina ($\chi^2 = 4.4476$, $df = 1$, $p = .035$). Even at Naranjo, where bracket-**u** accounts for a striking 77.0% of all **u** hieroglyphs, the sign is significantly overrepresented among spellings of the ergative pronoun *u-* (88.0%; $\chi^2 = 6.5415$, $df = 1$, $p = .011$; Table 2).

Bracket-**u** was the most common **u** hieroglyph throughout the history of Classic Maya writing (Brewer, 1998; Thompson, 1950, p. 188). Nonetheless, noticeable distinctions between sites suggest that the grapheme's distribution reflects local scribal preferences rather than orthographic prescriptions. Cancuen, Pomona, and Palenque stand out among the 19 dynastic centers for the low frequency with which local scribes recorded bracket-**u** (Fig. 4c; Table 1). The robust epigraphic sample at Palenque in particular attests that bracket-**u** was relative unpopular there, both specifically as an ergative pronoun (21.6%) and generally across all contexts (18.4%; Tables 1 and 2). Conversely, scribes at neighboring Piedras Negras (66.1%, $n = 127$) and Yaxchilan (66.1%, $n = 205$) relied on bracket-**u** to write the pronoun *u-* to a quite similar degree (Fig. 4a,b; Table 2). In both centers, the frequency of bracket-**u** in pronominal contexts is significantly higher than one would expect based on the proportion of **u** syllables

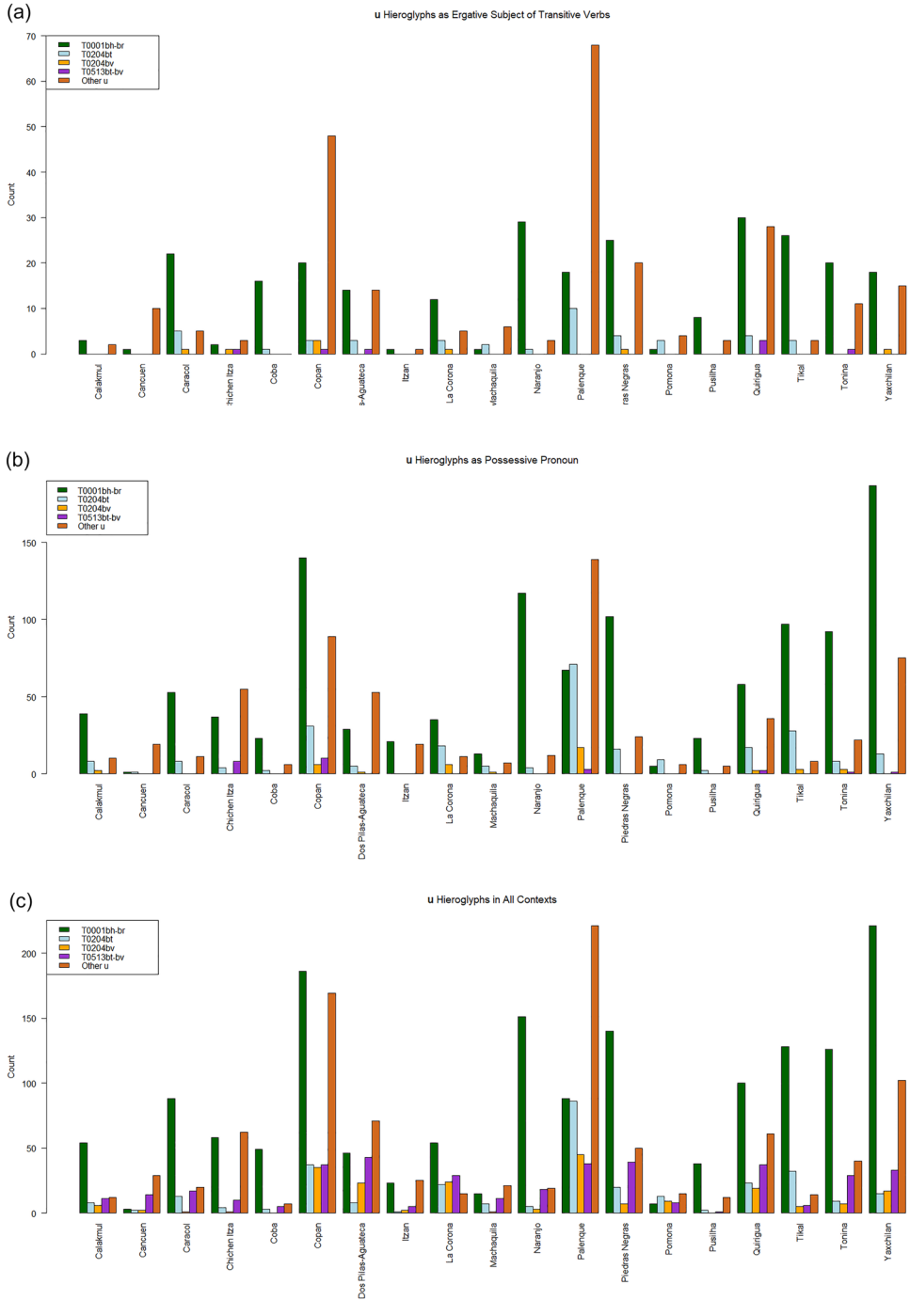

Fig. 4. Bar charts showing the distribution of **u** syllabic hieroglyphs in texts from 19 Classic Maya dynastic centers (a) as third-person singular possessive pronouns, (b) as third-person singular subject pronouns of transitive verbs, and (c) across all contexts.

Fig. 5. Examples of **u** hieroglyphs (outlined in yellow) in forms of the intransitive stem *uht* "happen, occur": T0513bv (a), T0513bt (b, d), T0204bv (c), T0001br (e, g), T0204bt (f, h), compared to a spelling with the logograph **UH** (i). Photographs by the author; (a–c, e, h) courtesy of the Museo Nacional de Arqueología y Etnología de Guatemala, Guatemala City, (i) courtesy of the Museo de Sitio Pomona/INAH.

for which the grapheme accounts across all contexts (Piedras Negras: $\chi^2 = 5.516$, $df = 1$, $p = .019$; Yaxchilan: $\chi^2 = 5.7136$, $df = 1$, $p = .017$, respectively; Fig. 4c; Table 2; cf. Table 1). Given Piedras Negras and Yaxchilan's geographic proximity and long history of rivalrous interaction (see Golden, Scherer, Muñoz, & Vasquez, 2008; Martin & Grube, 2000, pp. 116–153), it is very likely that local scribes were cognizant of this convergence even as they cultivated other orthographic practices that distinguished their kingdoms' respective scribal traditions (see Matsumoto, 2022).

4.2. *Verbal forms of* uht *"happen, occur"*

The distributions of jar-**u** and fish-**u** diverged from head-**u** and bracket-**u** relatively early (Matsumoto, 2021, pp. 418–424). Whereas the latter two were more closely linked with ergative pronouns, jar-**u** and fish-**u** soon became associated with syllabic spellings of the intransitive stem *uht*. It was most often written in the completive/past form *uhtiiy* "it happened" or the incompletive/present form *i-uht* "it happens," and less frequently in the potential/future form *uhtoom* "it will happen" (Figs. 5 and 6; Table 3; for a recent overview of the debate about temporal reference in Classic Mayan, see Law & Stuart, 2017, p. 168). In some cases,

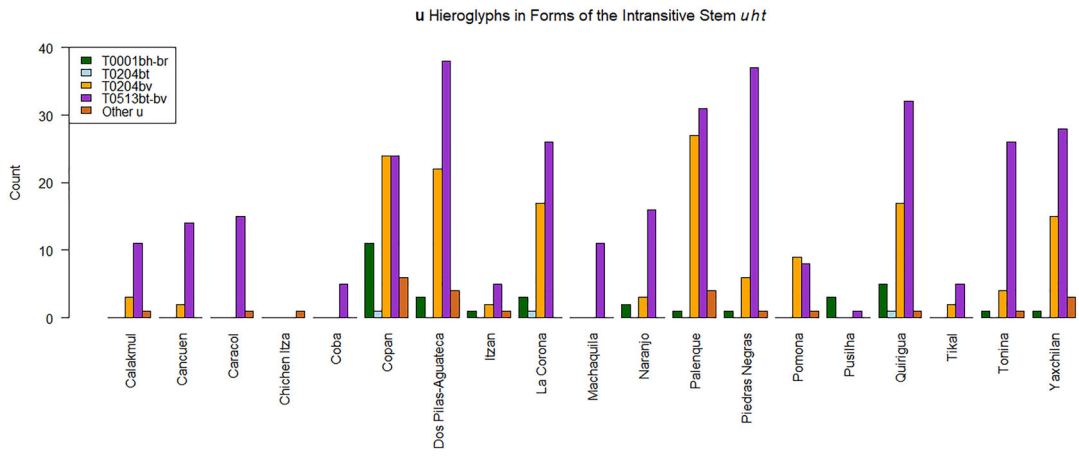

Fig. 6. Bar charts showing the distribution of **u** hieroglyphs in texts from 19 Classic Maya dynastic centers in syllabic spellings of the intransitive stem *uht*.

forms of the intransitive stem were spelled with the logograph **UH** (Fig. 5i), a practice that was particularly common at Tikal. However, scribes clearly favored a syllabic rendering of *uht* throughout the Classic period (Fig. 5a–h; Matsumoto, 2021, p. 423).

The earliest securely dated attestation of jar-**u** in a form of *uht* is an instance of T0513bv on Uaxactun Stela 26 (445 CE; Fig. 5a). It predates the first attestation of fish-**u** in an *uht* spelling by more than a century and a half (Piedras Negras Stela 25, 608 CE). The fish-**u** grapheme was never particularly popular in the larger assemblage of **u** hieroglyphs, however, especially compared to jar-**u** (Table 1). Until the late seventh century, the latter was initially more evenly distributed between spellings of the third-person singular ergative pronoun *u-* and the intransitive stem *uht* (Fig. 3d). However, all but a few dozen of the more than 350 Late Classic occurrences of jar-**u** among the 19 centers were written in a form of the intransitive stem (Fig. 5a,b,d; Tables 1 and 3; cf. Fig. 3h). Together, jar-**u** and fish-**u** account for at least 72.8% of syllabic *uht* spellings at 17 of the 19 dynastic centers, with Cancuen, Coba, Machaquila, and Tikal topping out at 100% (Fig. 6; Table 3). The only exceptions are Pusilha and Chichen Itza, which have the smallest samples of *uht* forms (Table 3).

For jar-**u** and especially its allograph T0513bv, association with the intransitive stem *uht* was very robust and persisted throughout the Classic period, as Brewer (1998, p. 5) previously observed. Of the two dozen occurrences of T0513bv considered in this study, only three appear outside of an *uht* spelling. Comparison with other **u** hieroglyphs underscores scribes' clear preference for jar-**u** in this orthographic context, even relative to fish-**u** (Fig. 6; Table 3). Whereas bracket-**u** and head-**u** were widely deployed to represent the third-person singular ergative pronoun *u-*, neither grapheme accounts for more than 9.5% of *uht* spellings at any of the 19 centers except for Copan, Itzan, and Pusilha (Fig. 6).

The discrepancy is especially pronounced for bracket-**u**, which is significantly underrepresented in *uht* spellings at 13 of 19 sites despite being the most common **u** hieroglyph generally (Fig. 5e,g; Table 3). Notably, the relatively limited instances of bracket-**u** in spelling

Table 3
Distribution of **u** hieroglyphs in syllabic spellings of the intransitive stem *uht* "happen, occur" in texts from 19 Classic Maya dynastic centers. Percentage totals may deviate slightly from 100% due to rounding

	T0001bh-br (% Total)	T0204bt (% Total)	T0204bv (% Total)	T0513bt-bv (% Total)	Other **u** (% Total)	Total *uht* Spellings
Calakmul	0[a]	0	3 (21.4)	11 (78.6)[b]	1 (7.1)	15
Cancuen	0	0	2 (12.5)	14 (87.5)[a]	0	16
Caracol	0[a]	0	0	15 (93.8)[b]	1 (6.3)	16
Chichen Itza	0	0	0	0	1 (100)	1
Coba	0[b]	0	0	5 (100)[b]	0	5
Copan	11 (16.7)[a]	1 (1.5)	24 (36.4)[a]	24 (36.4)[a]	6 (9.1)	66
Dos Pilas/Aguateca	3 (4.5)[a]	0	22 (32.8)[a]	38 (56.7)[a]	4 (6.0)	67
Itzan	1 (11.1)	0	2 (22.2)	5 (55.6)[b]	1 (11.1)	9
La Corona	3 (6.4)[a]	1 (2.1)[a]	17 (36.2)[a]	26 (55.3)[a]	0	47
Machaquila	0	0	0	11 (100)[b]	0	11
Naranjo	2 (9.5)[a]	0	3 (14.3)[b]	16 (76.2)[b]	0	21
Palenque	1 (1.6)[a]	0[a]	27 (42.9)[a]	31 (49.2)[a]	4 (6.3)	63
Piedras Negras	1 (2.2)[a]	0	6 (13.3)[b]	37 (83.2)[a]	1 (2.2)	45
Pomona	0	0[b]	9 (50.0)[a]	8 (44.4)[b]	1 (5.6)	18
Pusilha	3 (75.0)	0	0	1 (25.0)	0	4
Quirigua	5 (8.9)[a]	1 (1.8)	17 (30.4)[a]	32 (57.1)[a]	1 (1.8)	56
Tikal	0[b]	0	2 (28.6)[b]	5 (71.4)[b]	0	7
Tonina	1 (3.1)[a]	0	4 (12.5)[b]	26 (81.3)[a]	1 (3.1)	32
Yaxchilan	1 (2.1)[a]	0	15 (31.9)[b]	28 (59.6)[a]	3 (6.4)	47

[a]The hieroglyph's frequency, compared to all other **u** hieroglyphs in *uht* spellings, differs from its frequency among **u** hieroglyphs across all contexts (see Table 1) at a statistically significant level ($df = 1$, $p > .05$), based on Pearson's chi-square test of independence. See Supporting Information for results of individual chi-square tests.

[b]The hieroglyph's frequency, compared to all other **u** hieroglyphs in *uht* spellings, differs from its frequency among **u** hieroglyphs across all contexts (see Table 1) at a statistically significant level ($df = 1$, $p > .05$), based on Fisher's exact test. See Supporting Information for results of individual Fisher's exact tests.

the intransitive stem are concentrated in renderings of the future form, *u-toom*. The jar-**u** grapheme, in contrast, represents at least half of all syllabic *uht* forms at 15 of the 19 centers, a statistically significant increase relative to its proportion of **u** hieroglyphs generally (Fig. 6; Table 3). Even at Palenque, Pomona, and Copan, where jar-**u** occurs in less than 50% of syllabic *uht* spellings, the grapheme still occurs significantly more often than one would expect based on its representation among **u** syllables across all contexts (Table 3; cf. Table 1).

5. Conclusion

By the Early Classic period, Maya scribes developed more graphemes disposal to write the **u** syllable than any other linguistic value. In theory, the hieroglyphic script's structure permitted free variation among the phonetically equivalent signs, and scribes did take ample advantage of the graphic flexibility to avoid repeating signs within and between

texts. But throughout the Classic era and especially during the Late Classic period, hieroglyphic texts demonstrate a scribal trend toward complementary distribution of the graphemes bracket-**u**, head-**u**, jar-**u**, and fish-**u**. Whereas the first two were primarily written in third-person singular ergative pronominal contexts, the latter two graphemes became closely associated with syllabic spellings of the intransitive stem *uht*.

A sound explanation for the source of the associations remains out of reach, especially given the sparse Preclassic attestations of the script and the lack of clear iconographic origins for jar-**u** and especially bracket-**u**. In the case of the piscatory graphemes head-**u** and fish-**u**, we may speculate that their differential distribution responded at least in part to their distinct forms (Fig. 2c,f). For morphosyntactic and compositional reasons, the ergative pronoun *u-* was more likely to be prefixed at the beginning—and thus at the outer edges—of a glyph block (Fig. 3a,b,e,f). Thus, scribes may have considered the narrow body of head-**u**, as well as bracket-**u**, more suited to writing the pronoun *u-* (Fig. 2a,b). Fish-**u** and jar-**u**, in contrast, have the rounded contour typical of logographs and other signs written in the center of a glyph block, an area more typically, albeit not exclusively, occupied by lexemes or stems. Perhaps for that reason, both were both much more likely to be written in spellings of the intransitive stem *uht* (Figs. 2d,e and 5a–d; though cf. Fig. 3c,g–h).

Classic Maya scribal communities never adopted a unified system of morphosyntactic correspondences as demonstrated by the immense local and regional diversity in the hieroglyphs used in writing. From a practice-oriented perspective, the contextual salience attributed to each hieroglyph was neither an episodic nor an intentional innovation. Instead, the correspondences represent an outcome of gradual, collective, often unconscious scribal efforts to order the many hieroglyphic variants in circulation, just as speakers tend to gradually regularize variation in spoken language over time (see Labov, 1972, pp. 1–2; Lahiri, 2000; McMahon, 1994).

In semiotic terms, the systematization of **u** graphemes transformed arbitrary, written symbols to hieroglyphic indices of specific linguistic values by associating each sign with a particular morphosyntactic context (see Peirce, 1985). The indexicalizing trajectory of the **u** syllabic signs was likely encouraged by its interpretative benefits for the script's users. Even semi-conventionalized sign-context correspondences among linguistically equivalent hieroglyphs would have lowered processing load (cf. Balota, Cortese, Sergent-Marshall, Spieler, & Yap, 2004; Baron & Thurston, 1973; Carr, Posner, Pollatsek, & Snyder, 1979; Sakurai et al., 2000). Regularizing sign distribution according to morphosyntactic context would have increased transparency—a change that would have been especially helpful for readers confronting the myriad manifestations of the near-ubiquitous Classic Mayan syllable /ʔu/. Experiments indicate that Japanese readers, for example, process familiar spellings, which may include phonetic *kana* or morphographic *kanji*, more effectively than unfamiliar *kana* spellings because the former depend less on phonological information (Sakurai et al., 2000). Similarly, associating bracket-**u** and head-**u** with the ergative pronoun *u-* and jar-**u** and fish-**u** with forms of *uht* would have provided Classic Maya readers with more interpretative predictability.

The complementary distribution of the four **u** graphemes discussed here almost certainly resulted from a series of incremental changes over many generations. The process attributed

new meaning to existing graphic differences by allocating different roles to hieroglyphs that were linguistically equivalent and, as syllabic signs, carried no inherent semantic value. Still, even the complementarily distributed **u** graphemes do not appear to have functioned as so-called morphosyllables (see Gronemeyer, 2011; Houston et al., 2001, pp. 13–24). In spellings of the intransitive *uht*, the **u** grapheme indicated (part of) the stem rather than derivational or inflectional morphology (cf. Houston et al., 2001, p. 15). Moreover, there is no evidence, that scribes systematically used **u** hieroglyphs to indicate the prevocalic allomorph of the third-person singular ergative pronoun *y*-, as one would expect in the case of a morphosyllable. On the contrary, they consistently wrote that pronominal form with a **yV** syllabic hieroglyph whose vowel corresponded to the onset of the root to which *y*- was prefixed.

Finally, the multi-generational duration and broad geographic expanse of the complementary morphosyntactic distribution of bracket-**u**, head-**u**, fish-**u**, and jar-**u** provide compelling evidence that transmission of Maya hieroglyphic practice encompassed more than basic knowledge of sign–sound correspondences. In addition, it entailed an understanding of each sign's function within the writing system and the degree to which individual practitioners and scribal communities could negotiate that role. With **u** syllables in particular, Classic Maya scribes were operating in a landscape of significant hieroglyphic variation and experimentation in which sign–sound correspondences were often multiple and not equally represented in the production of every workshop. At the same time, scribes remained aware of and in many cases perpetuated regional trends that, while never absolute, point to extensive, continuous exchange among each other and engagement with texts produced by other workshops. Complementary distribution of **u** syllabic hieroglyph according to grammatical or lexical context offers a small glimpse of what were surely much more dynamic, layered processes of communication through which scribes maintained a mutually legible writing system over centuries, hundreds of kilometers, and political differences.

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Notes

1 https://classicmayan.org/zeichenkatalog/.

2 Preliminary copies of the Filemaker database and its exported contents in CSV format are available at https://doi.org/10.26300/wcfe-5731 and https://doi.org/10.26300/ev28-ax80, respectively. See Matsumoto (2021, pp. 50–51, App. 2) for more information about the database's creation and structure.

3 Pearson's test was used for all chi-square tests of independence, with Yates' Correction for continuity automatically applied to all 2 x 2 contingency tables ($df = 1$). Fisher's exact test was used in place of Pearson's chi-square test for smaller samples in which at least one cell in the 2×2 contingency table had an expected count of $n \leq 5$. All statistical tests were conducted using the open-source software R and an alpha level of $p = .05$. See Supporting Information for results of all individual chi-square and Fisher's exact tests.

4 The phrase *u-kabijiiy* typically heads an oblique clause that introduces the individual sponsoring or overseeing the main event under discussion. I tentatively analyze the phrase's *u-* prefix as an occurrence of the third-person singular ergative pronoun for the subject of transitive verbs but acknowledge that the linguistic analysis of *u-kabijiiy* remains subject to debate. Law and Stuart (2017, p. 164) note that the phrase functions as a relational noun, a special class of nouns in Mayan languages that fulfills many functions typical of prepositions in English, but that it "is unclear whether these phrases [relational nouns] are transitive verbs or possessed nouns," citing MacLeod (2004) and Robertson, Houston, and Stuart (2004).

References

Balota, D. A., Cortese, M. J., Sergent-Marshall, S. D., Spieler, D. H., & Yap, M. J. (2004). Visual word recognition of single-syllable words. *Journal of Experimental Psychology*, *133*(2), 283–316.

Baron, J., & Thurston, I. (1973). An analysis of the word-superiority effect. *Cognitive Psychology*, *4*(2), 207–228. https://doi.org/10.1016/0010-0285(73)90012-1

Barteld, F., Hartmann, S., & Szczepaniak, R. (2016). The usage and spread of sentence-internal capitalization in Early New High German: A multifactorial approach. *Folia Linguistica*, *50*(2), 385–412. https://doi.org/10.1515/flin-2016-0015

Bock, M., Augst, G., & Wegner, I. (1985). Groß oder klein? Zur Funktion des Wortanfangs für den gegenwärtigen Leser. *Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie*, *17*, 191–209.

Bock, M., Hagenschneider, K., & Schweer, A. (1989). Zur Funktion der Groß- und Kleinschreibung beim Lesen deutscher, englischer und niederländischer Texte. In P. Eisenberg & H. Günther (Eds.), *Schriftsystem und Orthographie* (pp. 23–56). Berlin: De Gruyter. https://doi.org/10.1515/9783111372266.23

Brewer, S. (1998). *The ergative pre-consonant u glyph in Classic Maya inscriptions* (Unpublished term paper in possession of the author). Brigham Young University.

Bricker, V. R. (1986). *A grammar of Mayan hieroglyphs*. New Orleans, LA: Middle American Research Institute Tulane University.

Busse, A. (2013). Hittite scribal habits: Sumerograms and phonetic complements in Hittite cuneiform. In E. -M. Wagner, B. Outhwaite, & B. Beinhoff (Eds.), *Scribes as agents of language change* (pp. 85–96). Boston, MA: Walter de Gruyter. https://doi.org/10.1515/9781614510543.85

Carr, T. H., Posner, M. I., Pollatsek, A., & Snyder, C. R. (1979). Orthography and familiarity effects in word processing. *Journal of Experimental Psychology*, *108*(4), 389–414. https://doi.org/10.1037/0096-3445.108.4.389

Coe, M. D., & Houston, S. D. (2022). *The Maya* (10th ed.). New York: Thames and Hudson.

de Bree, E., van der Ven, S., & van der Maas, H. (2017). The voice of Holland: Allograph production in written Dutch past tense inflection. *Language Learning and Development*, *13*(3), 215–240. https://doi.org/10.1080/15475441.2016.1217777

Defrancis, J. (1996). Graphemic indeterminacy in writing systems. *Word*, *47*(3), 365–377. https://doi.org/10.1080/00437956.1996.11432455

Demattè, P. (2022). *The origins of Chinese writing*. New York: Oxford University Press. https://doi.org/10.1017/S0959774310000247

Fox, J. A., & Justeson, J. S. (1984a). Appendix C: Conventions for the transliteration of Mayan hieroglyphs. In J. S. Justeson & L. Campbell (Eds.), *Phoneticism in Mayan hieroglyphic writing* (pp. 363–366). Albany, NY: Institute for Mesoamerican Studies No. 9, Institute for Mesoamerican Studies, State University of New York at Albany.

Fox, J. A., & Justeson, J. S. (1984b). Polyvalence in Mayan hieroglyphic writing. In J. S. Justeson & L. Campbell (Eds.), *Phoneticism in Mayan hieroglyphic writing* (pp. 17–76). Albany, NY: Institute for Mesoamerican Studies No. 9, Institute for Mesoamerican Studies, State University of New York at Albany.

Gfroerer, S., Günther, H., & Bock, M. (1989). Augenbewegungen und Substantivgroßschreibung—Eine Pilotstudie. In P. Eisenberg & H. Günther (Eds.), *Schriftsystem und Orthographie* (pp. 111–136). Berlin: De Gruyter. https://doi.org/10.1515/9783111372266.111

Golden, C., Scherer, A. K., Muñoz, A. R., & Vasquez, R. (2008). Piedras Negras and Yaxchilan: Divergent political trajectories in adjacent Maya polities. *Latin American Antiquity*, *19*(3), 249–274.

Goossens, J. (1994). Normierung in spätmittelalterlichen Schreibsprachen. *Niederdeutsches Wort*, *34*, 77–99.

Gronemeyer, S. (2011). Evoking the dualism of sign classes: A critique on the existence of morphosyllabic signs in Maya hieroglyphic writing. *Indiana*, *28*, 315–337. http://www.redalyc.org/pdf/2470/247022796014.pdf

Houston, S., & Martin, S. (2016). Through seeing stones: Maya epigraphy as a mature discipline. *Antiquity*, *90*(350), 443–455. https://doi.org/10.15184/aqy.2016.33

Houston, S., Robertson, J., & Stuart, D. (2000). The language of Classic Maya inscriptions. *Current Anthropology*, *41*(3), 321–356. https://doi.org/10.1086/300142

Houston, S., Robertson, J., & Stuart, D. (2001). Quality and quantity in glyphic nouns and adjectives. *Research Reports on Ancient Maya Writing*, *47*, 1–56.

Houston, S. D., Robertson, J., & Stuart, D. (2001). More on the language of Classic Maya inscriptions. *Current Anthropology*, *42*(4), 558–559. https://doi.org/10.1086/322544

Hruby, Z. X., & Child, M. (2004). Chontal linguistic influence in ancient Maya writing: Intransitive positional verbal affixation. In S. Wichmann (Ed.), *The linguistics of Maya writing* (pp. 13–26). Salt Lake City, UT: University of Utah Press.

Josserand, J. K., & Hopkins, N. A. (2002). Classic Maya social interaction and linguistic practice: Evidence from hieroglyphic inscriptions and Mayan languages. In V. Tiesler Blos, R. Cobos, & M. G. Robertson (Eds.), *La organización social entre los mayas* (Vol. 2, pp. 355–372). Mexico City: Instituto Nacional de Anthropología e Historia.

Justeson, J. S. (1989). The representational conventions of Mayan hieroglyphic writing. In W. F. Hanks & D. S. Rice (Eds.), *Word and image in Maya culture: Explorations in language, writing, and representation* (pp. 25–38). Salt Lake City, UT: University of Utah Press.

Justeson, J. S., & Campbell, L. (Eds.). (1984). *Phoneticism in Mayan hieroglyphic writing*. Albany, NY: Institute for Mesoamerican Studies, State University of New York at Albany.

Kudrinski, M., & Yakubovich, I. (2016). Sumerograms and Akkadograms in Hittite: Ideograms, logograms, allograms, or heterograms? *Altorientalische Forschungen*, *43*(1-2), 53–66. https://doi.org/10.1515/aofo-2016-0018

Labov, W. (1972). *Sociolinguistic patterns*. Philadelphia, PA: University of Pennsylvania Press.

Lacadena García-Gallo, A. (2000). Antipassive constructions in the Maya glyphic texts. *Written Language and Literacy*, *3*(1), 155–180.

Lacadena García-Gallo, A., & Wichmann, S. (2019). Harmony rules and the suffix domain: A study of Maya scribal conventions. *Revista Española de Antropología Americana*, *49*, 183–208. https://doi.org/10.5209/reaa.64966

Lahiri, A. (Ed.). (2000). *Analogy, levelling, markedness: Principles of change in phonology and morphology*. Berlin: De Gruyter.

Laroche, E. (1978). Problèmes de l'écriture cunéiforme hittite. *Annali della Scuola Normale Superiore di Pisa. Classe di Lettere e Filosofia*, *8*(3), 739–753.

Law, D. (2014). *Language contact, inherited similarity and social difference: The story of linguistic interaction in the Maya lowlands*. Amsterdam, the Netherlands: John Benjamins.

Law, D., Robertson, J., & Houston, S. D. (2006). Split ergativity in the history of the Ch'olan branch of the Mayan language family. *International Journal of American Linguistics*, *72*(4), 415–450. https://doi.org/10.1086/513056

Law, D., & Stuart, D. (2017). Classic Mayan: An overview of language in ancient hieroglyphic script. In J. L. Aissen, N. C. England, & R. Zavala Maldonado (Eds.), *The Mayan languages* (pp. 128–172). London: Routledge.

Lurie, D. B. (2011). *Realms of literacy: Early Japan and the history of writing*. Cambridge, MA: Harvard University Press. https://doi.org/10.1163/9781684175086

MacLeod, B. (2004). A world in a grain of sand: Transitive perfect verbs in the Classic Maya script. In S. Wichmann (Ed.), *The linguistics of Maya writing* (pp. 291–325). Salt Lake City, UT: University of Utah Press.

Martin, S. (2020). *Ancient Maya politics: A political anthropology of the Classic period 150–900 CE*. Cambridge: Cambridge University Press.

Martin, S., & Grube, N. (2000). *Chronicle of the Maya kings and queens: Deciphering the dynasties of the ancient Maya*. London: Thames and Hudson.

Matsumoto, M. E. (2021). *Sharing script: Development and transmission of hieroglyphic practice among Classic Maya scribes* (Doctoral dissertation). Brown University.

Matsumoto, M. E. (2022). Escribiendo al lado del Río Usumacinta. La transmisión jeroglífica en los reinos mayas de Piedras Negras y Yaxchilan durante el Periodo Clásico. In B. Arroyo, L. Méndez Salinas, & G. Ajú Álvarez (Eds.), *XXXIV Simposio de Investigaciones Arqueológicas en Guatemala, 2021* (Vol. 2, pp. 913–928). Guatemala City, Guatemala: Ministerio de Cultura y Deportes, Instituto de Antropología e Historia, Asociación Tikal.

McMahon, A. (1994). *Understanding language change*. Cambridge: Cambridge University Press.

Meletis, D. (2019). The grapheme as a universal basic unit of writing. *Writing Systems Research*, *11*(1), 26–49. https://doi.org/10.1080/17586801.2019.1697412

Meletis, D., & Dürscheid, C. (2022). *Writing systems and their use: An overview of grapholinguistics*. Berlin: De Gruyter Mouton. https://doi.org/10.1515/9783110757835

Mora-Marín, D. F. (2010). Consonant deletion, obligatory synharmony, typical suffixing: An explanation of spelling practices in Mayan writing. *Written Language and Literacy*, *13*(1), 118–179. https://doi.org/10.1075/wll.13.1.05mor

Nowak, J., & Hartmann, S. (2024). The rise and fall of sentence-internal capitalization in English. In L. Caon, M. S. Gordon, & T. Porck (Eds.), *Unlocking the history of English: Pragmatics, prescriptivism and text types* (pp. 33–59). Amsterdam, the Netherlands: John Benjamins Publishing Company.

Peirce, C. S. (1985). Logic as Semiotics: The theory of signs. In R. E. Innis (Ed.), *Semiotics: An introductory anthology* (pp. 4–23). Indiana University Press.

Polis, S. (2017). The scribal repertoire of Amennakhte Son of Ipuy: Describing variation across late Egyptian registers. In J. Cromwell & E. Grossman (Eds.), *Scribal repertoires in Egypt from the new kingdom to the early Islamic period* (pp. 89–126). Oxford, England: Oxford University Press. https://doi.org/10.1093/oso/9780198768104.003.0005

Prager, C. M., & Gronemeyer, S. (2018). Neue Ergebnisse in der Erforschung der Graphemik und Graphetik des Klassischen Maya. In S. A. Gülden, K. V. J. van der Moezel, & U. Verhoeven-van Elsbergen (Eds.), *Ägyptologische "Binsen"-Weisheiten III: Formen und Funktionen von Zeichenliste und Paläographie* (pp. 135–181). Stuttgart, Germany: Franz Steiner Verlag. https://doi.org/10.25358/openscience-4977

Robertson, J., Houston, S., & Stuart, D. (2004). Tense and aspect in Maya hieroglyphic script. In S. Wichmann (Ed.), *The linguistics of Maya writing* (pp. 259–289). The Salt Lake City, UT: University of Utah Press.

Ryholt, K. (2017). Scribal habits at the Tebtunis Temple Library: On materiality, formal features, and palaeography. In J. Cromwell & E. Grossman (Eds.), *Scribal repertoires in Egypt from the New Kingdom to the early Islamic period* (pp. 153–183). Oxford, England: Oxford University Press. https://doi.org/10.1093/oso/9780198768104.003.0007

Sakurai, Y., Momose, T., Iwata, M., Sudo, Y., Ohtomo, K., & Kanazawa, I. (2000). Different cortical activity in reading of Kanji words, Kana words and Kana nonwords. *Cognitive Brain Research*, *9*(1), 111–115. https://doi.org/10.1016/S0926-6410(99)00052-X

Stone, A., & Zender, M. (2011). *Reading Maya art: A hieroglyphic guide to ancient Maya painting and sculpture*. London: Thames and Hudson.

Stuart, D. (1990). The decipherment of "Directional Count Glyphs" in Maya inscriptions. *Ancient Mesoamerica*, *1*(2), 213–224.

Stuart, G. E. (1988). A guide to the style and content of the series research reports on ancient Maya writing. *Research Reports on Ancient Maya Writing*, *15*, 7–10. http://caracol.org/include/files/chase/cgc91.pdf

Thompson, J. E. S. (1950). *Maya hieroglyphic writing: Introduction*. Washington, DC: Carnegie Institution of Washington.

Thompson, J. E. S. (1962). *A catalog of Maya hieroglyphs*. Norman, OK: University of Oklahoma Press. https://doi.org/10.2307/2510061

Thompson, J. E. S. (2001). [1944]. The fish as a Maya symbol for counting and further discussion of directional glyphs. In Houston, O. Chinchilla Mazariegos, & D. Stuart (Eds.), *The decipherment of ancient Maya writing* (pp. 127–143). Norman, OK: University of Oklahoma Press.

Wald, R. (2004). The languages of the Dresden Codex: Legacy of the Classic Maya. In S. Wichmann (Ed.), *The linguistics of Maya writing* (pp. 27–58). Salt Lake City, UT: University of Utah Press.

Weeden, M. (2011). *Hittite logograms and Hittite scholarship*. Wiesbaden, Germany: Harrassowitz.

Wu, Y., Tsang, Y. -K., Wong, A. W. -K., & Chen, H. -C. (2017). The processing of homographic morphemes in Chinese: An ERP study. *Language, Cognition and Neuroscience*, *32*(1), 102–116. https://doi.org/10.1080/23273798.2016.1227857

Zhou, X., Marslen-Wilson, W., Taft, M., & Shu, H. (1999). Morphology, orthography, and phonology reading Chinese compound words. *Language and Cognitive Processes*, *14*(5-6), 525–565. https://doi.org/10.1080/016909699386185

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