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CARDINAL NUMERALS IN AKAN: A CONSTRUCTION MORPHOLOGY ACCOUNT

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This paper presents a Construction Morphology account of complex cardinal numeral formation in Akan (Kwa, Niger-Congo). Through a detailed description of the Akan numeral system, which is decimal, we identify various ranges of cardinal numerals and show that they share structures with other constructions in the language because they are either compounds or coordinate constructions. We show that, consistent with crosslinguistic patterns, the two arithmetic operations that underpin the construction of cardinal numerals in Akan are addition and multiplication and they are formally realised differently. While multiplication is manifested mainly as compounding (and reduplication), addition is expressed mainly through compounding and coordination. The Construction Morphology framework allows us to account for the full range of Akan cardinal numerals in a consistent manner, showing how numerals relate to other constructions in the language. We posit two constructional schemas for the two arithmetic operations, with various subschemas for different instantiating constructions, including some constructional idioms in which certain recurrent forms are pre-specified.

Keywords: Akan, cardinal numeral, Construction Morphology, constructional idiom, template unification

Introduction

The nature and function of numbers and numerals[1] have received considerable scholarly attention from diverse fields, including Philosophy, Psychology, Neuroscience, Mathematics and Linguistics. The issues that have engaged the attention of most linguists include the syntactic category and distribution of numerals, the formal make-up and meaning of numeral constructions as well as the discovery of rules for generating all and only the well-formed numerals in a language (van Katwijk 1965, 1968; Brainerd 1966, 1968b; Brainerd & Peng 1968; Brandt Corstius 1968; Siromoney 1968; Hurford 1975; Stampe 1976; Corbett 1978a, 1978b; Stump 2010; Comrie 2011;

[1] In this paper, we use the term *numeral* (Num) to refers to linguistic expressions and *number* (NUM) to refer to the value of a linguistic expression.

Epps et al. 2012). Other linguists, psycholinguists and neuroscientists, believing in the psychological reality of the activity of counting, seek to find the biological foundations of the number sense (Dehaene 1997, 2001; Seron & Pesenti 2001) and its socio-cultural and cognitive motivation (Hurford 1987, 2007; Wiese 2003a, 2003b, 2007; Gordon 2004; Gelman & Butterworth 2005; Epps 2006). These studies show that numeral systems distinguish between two basic types of numerals – primary numerals and complex numerals, the latter built out of the primary numerals. Two important factors underpin their formation. One is the arithmetic operations employed, which may be one of the four identified cross-linguistically – addition, subtraction, multiplication, or division. The other is the morphological and/or syntactic processes involved, which may be affixation, compounding, juxtaposition, reduplication or coordination (Greenberg 1978).

Although the properties of Akan numerals have not featured in the theoretical literature on numerals, this is not the first study on Akan numerals. Christaller (1875: 50-55) describes Akan numerals, distinguishing between *definite numerals* (e.g., *du* ‘ten’) which denote exact numbers and *indefinite numerals* (e.g., *pii* ‘many’, *nyina* ‘all’ & *bi* ‘some’) which do not denote exact numbers. He treats the former as (abstract) nouns and the latter as adjectives. He also categorizes numerals formally into *primary* and *compound* numerals and functionally into *cardinal*, *iterative*/*multiplicative*, *distributive*, *ordinal* and *fractional* numerals. Balmer & Grant (1929) and Dolphyne (1996) cite numerals from the Fante and Asante dialects respectively, but do not analyse them. Ofori (2008) discusses a subset of cardinal numerals (20-90 and 200-900) in the Asante and Akyem dialects. He recognises them as compounds and attempts to account for the morphophonological processes (vowel harmony, deletion, compensatory lengthening, etc.) which occur at the boundary between constituents to ensure the well-formedness of the numerals. Ofori’s study, though limited in coverage, shows that, in their formal makeup, those Akan numerals are compounds. Finally, in some recent studies focused on the properties of non-cardinal numerals (Appah 2019a, 2019b; Appah et al. 2019) it is shown that these non-cardinal numerals share formal structures with other morphological and syntactic constructions in Akan.

What remains largely undone is a detailed theoretical study of Akan cardinal numerals, and the present paper is a modest attempt towards filling the gap. The purpose is to study the internal grammar of Akan complex cardinal numerals like those in (1) and to present a Construction Morphology account of their properties, showing the units and the arithmetic operation that underly the formation of the numerals as well as how the structure of cardinal numerals relates to other constructions in Akan. We also attempt to explain the semblance between the structure of complex cardinal numerals and other morphological and syntactic constructions in the language.

(1)	**du-biako**	‘11’	[lit. ten-one]
	e-du-onu anan	‘24’	[lit. PL-ten-two four]
	ɔ-ha e-du-asa ebien	‘132’	[lit. SG-hundred PL-ten-three two]
	a-ha-esia	‘600’	[lit. PL-hundred-six]
	m-pem ebien	‘2000’	[lit. PL-thousand two]

Through a detailed analysis of the data, we seek to answer the following questions: What are the classes of cardinal numerals in Akan? What arithmetic operations underpin the formation and interpretation of Akan complex cardinal numerals? Are there any formal means of marking the arithmetic operation in the numerals? How do we explain the structural similarity between cardinal numerals and other constructions in Akan?

The data and analysis presented in this study will show the following: (i) Akan complex cardinal numerals fall into well-defined groups, showing patterns of regularities; (ii) the formation and interpretation of the numerals is underpinned by specific arithmetic operands which may have specific formal representation in the form of functional elements like the conjunction **ne/na** 'and' which marks addition in numerals with values greater than *one hundred*; (iii) the regularities in the structure of Akan complex cardinal numerals and the similarity between them and other complex words and phrases are not unexpected, given that the processes used in numeral formation are the same ones employed in forming other morphological and syntactic constructions in the language; (iv) each group of numerals may be formalized as a constructional schema, but the complexity of some numeral constructions suggests that they result from the conflation of the schemas of more basic constructions. We note that the potential multiple inheritance that gives rise to such multiply complex numerals may be seen as the result of *template unification* (Booij 2007; Appah 2017c). The constructionist view of the lexicon as a *construction* (Jurafsky 1992: 8), the repository of a hierarchically structured network of constructions sharing multiple inheritance relations, makes it possible for a construction to inherit properties from more than one construction.

We start with a brief review of some pertinent distinctions in the study of numeral systems, where we point out the primary distinction between primary and complex cardinal numerals. This is followed by an equally brief introduction to Construction Morphology, the theoretical framework for the study. Next, we discuss the construction of Akan cardinal numerals followed by the conclusion of the study.

Numeral systems, numeral formation, and underpinning arithmetic operations

Greenberg's first Generalization about numeral systems states that "[e]very language has a numeral system of finite scope" (Greenberg 1978: 253). These numeral systems tend to behave like subsystems within languages with their own internal grammar and exhibit remarkable cross-linguistic uniformity which may be attributable to the logical and cognitive requirement that, to serve their purpose, numbers must be ordered sequences of well-distinguished entities. The systemic numerals correspond to the counting words in the conventionalized counting sequence, the cardinal numerals, which occur recursively as constituents of more complex higher-valued numerals and may underlie the formation of corresponding forms of other numeral types – ordinal, multiplicative, frequentative, etc. (cf. Hurford 2001; von Mengden 2010; Stump 2010).

Systemic numerals are categorized into two basic types – primary and complex (sometimes called compound) numerals. Primary numerals are the unmotivated, usually mono-morphemic, units. They typically include all numerals up to and including the base numeral. For decimal numeral systems like Akan and English, for example, they include *one* to *nine*, *ten*, (even *eleven* & *twelve* in contemporary English), and some multiples of *ten* like *hundred* and *thousand*.

The primary numerals divide functionally into atoms (1-9) and bases (10, 100 and 1000), whose complementary properties are crucial for the formation of complex numerals and for the overall structure of the numeral system. Atoms, also called digital numerals (Hurford 2007), are elements of numeral systems with the highest potential of forming a continuously recurring (sub)-sequence of numerals in combination with bases or their multiples (von Mengden 2010: 39). Comrie (2011) defines the "base" of a numeral system as "the value *n* such that numeral expressions are constructed according to the pattern ... $xn + y$, i.e., some numeral x multiplied by the base plus some other numeral [y]". Here, the order of elements may be language-specific. Thus, bases are characterized as elements that combine with atoms, or paradigmatic choice out of a sequence of atoms (cf. von Mengden 2010: 33). The lowest base number is the *fundamental base* (Greenberg 1978) and it may occur in various forms in its multiple.

Complex numerals are made up of two or more primary numerals. They are generated "recursively" from primary numerals and their interpretation is mediated by arithmetic operands – addition, subtraction, multiplication, or division. Of these four fundamental arithmetic operations attested in the languages of the world the commonest, cross-linguistically, are addition and multiplication (cf. generalization 9, Greenberg 1978). The arithmetic operations may not be overtly marked in the numeral. However, where they are marked, there are various options available, including lexical ones like 'with' and 'and', for addition, 'upon' for multiplication, 'from' for subtraction, etc. As will be shown below, in Akan, addition is formally marked with a lexical item, e.g., **ne/na**, only in cardinal numerals greater than one hundred (>100). Thus, numeral systems have two core components – a set of primary forms and a set of morphosyntactic rules that combine the primary forms into complex numerals whose formation may be a matter of morphology, syntax, or both. Therefore, complex numerals may surface as derived words, compounds, or phrases. For example, English *seventy* and *eighty* are clearly derived complex words consisting of the bases *seven* and *eight*, respectively, and the suffix *-ty*, meaning *ten*, while higher numerals like 'twenty-one' and 'forty-five', are mostly compounds, "a special type of compounds" (Dressler 2006: 25). In the same way, Akan numerals above *one hundred*, like 104 in (2), have the structure of coordinate constructions marked by the conjunction **na**.

(2)	**ɔ-ha**	**na**	**anan**
	SG-hundred	CONJ	four
	'(one/a) hundred and four'		

Here, internal commutability is prohibited, as the linear order of the conjuncts is fixed. If the order is reversed, the structure becomes ill-formed, as shown in (3). Again, without the conjunction, either a completely different numeral is formed (if **ɔha** 'hundred' is pluralized) or the expression becomes ungrammatical, as shown in (4).

(3) ***anan na ɔha**
four CONJ hundred

(4) **a-ha anan (*ɔha anan)**
PL-hundred four
'four hundred'

For numerals like (5), discerning whether it results from compounding (thus, morphology) or syntax is not straightforward. They may be considered syntactic because the constituents are written as separate words, but there is no overt maker of syntactic status. Sometimes, there may be an overt marker of the syntactic status, as the alternate expression in (6) shows.

(5) **ɔha eduasa ebien**
hundred thirty two
'(one) hundred and thirty-two'

(6) **ɔha na eduasa ebien**
hundred and thirty two
'(one) hundred and thirty-two'

Compared to (6), the traditional view of (5) might be that the conjunction is deleted or phonologically unrealized/empty (cf. Hurford 1975). However, we find no reason why (5) & (6) may not be regarded as two separate renditions of the intended meaning – a morphological rendition (5) and a syntactic rendition (6). Here, the usual test for lexical integrity, like the impossibility of inserting some matter between the parts of a word and internal inflection, may not help in determining the wordhood of the numeral because no Akan numeral permits the insertion of extraneous materials. However, plural marking may occur on any constituent whether the numeral is assumed to be formed morphologically or syntactically. This shows that numeral formation may involve both morphology and syntax and may be subject to specific restrictions on linear order, violating which the numerals become ill-formed.

It is for this reason that it is suggested that numerals constitute subsystems within languages with their own internal grammar, sometimes exhibiting typologically unusual characteristics and being subject to restrictions that other comparable constructions are not (cf. Dressler 2006: 25; Spencer 2011: 484). Notwithstanding this, it is observed that numeral formation seems to be so systematic/schematic that it must be seen as a rule-governed operation. That is, the numeral system of a language generates complex numerals from the stock of primary forms according to recursive rules and underlying arithmetic operations, so that any value can be expressed, in principle. The actual representation of this putative recursive process, however, depends on whether one sees numeral formation as syntactic or morphological. In keeping with the spirit of the times, most studies from the 1960s regarded numeral formation as a syntactic process (Brainerd 1966, 1968a, 1968b; Brainerd & Peng 1968; Merrifield 1968; Siromoney 1968; Van Katwijk 1968). This theoretical approach to studying numerals has persisted until now. Hurford (1975, 1987, 2007), for example, observes that the uniformity observed in the structure of complex numerals can be generated from the set of universal phrase structure (PS) rules in (7).

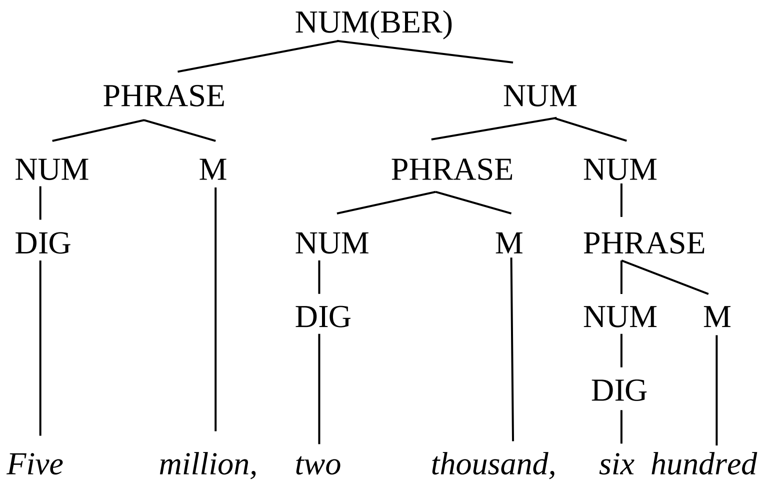
(7) Universal PS Rules (Hurford 2007: 774)

NUMBER	→	$\left\{ \begin{array}{c} \textbf{DIGIT} \\ \textbf{PHRASE (NUMBER)} \end{array} \right\}$	(interpreted by addition)
PHRASE	→	**(NUMBER)** **M**	(interpreted by multiplication)

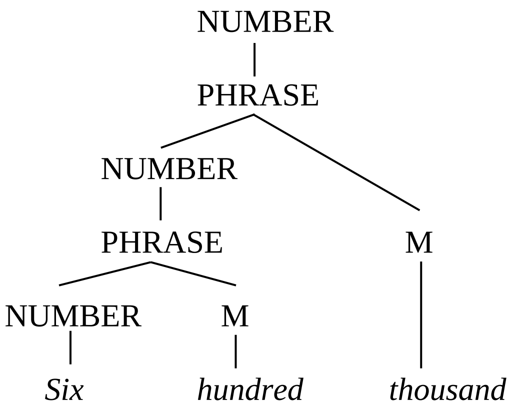
‘DIGIT’ represents single numeral words up to the base number. ‘M’ represents noun-like numerals, including *-ty*, *thousand* and *billion*, in a decimal system, used as multiplication bases (Hurford 2001: 10758).

The PS rules yield trees like (8) and (9), which are meant to show that numeral formation is ultimately a syntactic process, although there is no reason why the numerals in (8) and (9) cannot be regarded as compounds (consider, [[*Six hundred*]$_N$ *thousand*]$_N$), given that numerals may be subject to the same morphophonological processes as other compounds (cf. Ofori 2008).

(8)



(9)



(Hurford 2007: 775)

von Mengden (2010: 49) favours a morphological interpretation of numeral formation. He suggests that the difference between a primary numeral and a complex numeral is morphological because the primary numeral is mono-morphemic while the complex numeral consists of several constituents. However, this is problematic because the fact that a complex numeral consists of several constituents does not imply morphological formation.[2] As shown in (2), some complex numerals take the form of coordinate constructions with overt markers of coordination. Surely, English *one hundred <u>and</u> seven* '107' is syntactic and not morphological, unless one overlooks the coordinating conjunction. Thus, this morphology-only view will fail to account for the full range of numeral constructions. von Mengden is not unaware of this fact. He suggests, however, that whether the rules that form numerals are regarded as morphological or syntactic "will [...] ultimately remain a matter of the underlying theoretical approach" (von Mengden 2010: 41).

Although deciding on whether a form is syntactic or morphological may not be straightforward, as the discussion of (5) & (6) reveals, the decision cannot be as simply theory-dependent as von Mengden suggests. There should be theory-independent (probably language-specific) criteria for determining whether a process is morphological or syntactic. The popular lexical integrity tests come to mind, although they may not be wholly reliable, as noted above. von Mengden (2010: 41) makes an observation which we believe to be an apt description of what the structure of complex numerals reveals about the relationship between morphology and syntax. He observes that "whether a complex numeral is, in the particular case, best analysed as an affixation, a compound or a juxtaposition of co-ordinate syntactic phrases should be a question of locating areas in a continuum of possible structures rather than a categorial

[2] It should be noted that primary numerals may be morphologically segmentable in some languages. For instance, in Akan, lexical word classes except for verbs, usually have a prefix and/or suffix which marks grammatical number or some semantic category (see Osam 1994). Thus, in this paper the term primary is used to refer specifically to (digital) atoms and (non-digital) bases, independent of their internal morphological structure.

decision". This obviously constructionist view allows for a uniform treatment of all numeral constructions – morphological or syntactic (cf. Booij 2010; Jackendoff 1997).

We adopt a constructionist approach to the analysis of Akan complex cardinal numerals. This approach allows us to show how all kinds of constructions may unify to derive complex numerals. We present the Construction Morphology framework in the next section.

Construction Morphology

Construction Morphology (CxM) is an abstractionist word-based theory of linguistic morphology, which aims to provide a framework for adequately accounting for the differences and commonalities of word-level and phrase-level constructs (Booij 2010). CxM builds on insights from Construction Grammar, especially the central notion of *construction*, which is defined as a pairing of form and meaning (Goldberg 1995; Bybee 2013; Jackendoff 2008). Constructions may be built by means of schemas, which abstract over sets of existing complex forms and serve as a recipe for forming other constructions of comparable complexity (Booij 2007, 2010; Appah 2013). See, for example, the schema in (10) which generalizes over right-headed compounds.

(10) $\langle [[a]_{Xi}\ [b]_{Yj}]_{Yk} \leftrightarrow [\mathrm{SEM}_j \text{ with relation R to } \mathrm{SEM}_i]_k \rangle$

The upper-case variables X and Y represent the major lexical categories (V, N & A). The lower-case variable *a* and *b* stand for arbitrary strings of sounds, whilst *i*, *j* and *k* are indexes for the matching properties of the compound and its constituents (Booij 2010).

In CxM, schemas and their instantiating constructions co-exist in a hierarchically structured lexicon, where two types of relations hold – "instantiation", which obtains between a schema and a construction that is formed by the schema and "part of", which exists between a construction and its constituents. The relations are illustrated in (11), where each dominated schema instantiates the one that dominates it and the individual constituents, *school* and *uniform* are 'part of' the compound *school uniform*.

(11) $\langle [[a]_{Xi}\ [b]_{Yj}]_{Nk} \leftrightarrow [\mathrm{SEM}_j \text{ with relation R to } \mathrm{SEM}_i]_k \rangle$

$\langle [[\mathrm{N}]_i\ [\mathrm{N}]_j]_{Nk} \leftrightarrow [\mathrm{SEM}_j \text{ meant for } \mathrm{SEM}_i]_k \rangle$

$\langle [[\text{school}]_i\ [\text{uniform}]_j]_{Nk} \leftrightarrow [\text{uniform}_j \text{ meant for school}_i]_k \rangle$

$[\text{school}]_N$ $[\text{uniform}]_N$

Constructions are not expected to be compositional; they just have to be predictable. Thus, constructions may have properties that do not emanate from their constituents (Booij 2010; Appah 2015, 2017b). However, both compositional and extra-compositional properties of constructions can be accounted for without positing abstract categories to serve as the source of non-compositional properties (cf. Jackendoff 1997, 2002; Appah 2013, 2016b, 2017b).

A schema in which one of the slots is lexically specified is called a *constructional idiom* (Jackendoff 2002). Here, the pre-specified element is treated as part of the constructional schema, so that only the variable slot is available to be filled, on occasion, to instantiate the construction in concrete terms. We employ this feature prominently to show how general properties of the various classes of numerals discussed in this paper may be captured straightforwardly in (sub-)schemas that abstract over the properties of the classes of numeral constructions, with some recurrent forms pre-specified in the schema, making them constructional idioms.

One advantage of the view that actual constructions and the schema they instantiate occur in this hierarchically organized constructional space, called the *constructicon* (Jurafsky 1992), is that nuances in the semantic and formal properties of complex forms are not difficult to account for, since they can be related to regular patterns by positing subschemas. Another is that schemas can be unified through multiple inheritances, yielding multiply complex schemas. This is called template unification (TU), and it accounts for the simultaneous application of multiple processes, skipping any intermediate step(s), so that two independent processes, none of which seems to be sufficient to account for a complex constructions on their own, can apply simultaneously to form a multiply complex construction that can be said to have started a life of its own (Booij 2010).

Following Appah (2017c) we assume that TU occurs freely, to the extent that the properties of the unifying schemas do not conflict, and is enhanced when one schema has an open slot, with constraints that can be fully satisfied by the properties of the other schema. This possibility of unifying constructions freely to form actual expressions, so long as they do not conflict, coupled with the existence of constructions with open slots makes it possible to capture Chomsky's (1957, 1965) intuitions about the creative potential of language (cf. Appah 2017c).

The structure and formation of complex cardinal numerals

As discussed above, a numeral system consists of a set of primary numerals and a set of morphosyntactic rules that combine them into complex numerals whose interpretation is mediated by arithmetic operands. We present Akan primary digital numerals in Table 1 and the non-digital base numerals in Table 2.

Akan numerals are derived from nouns although they may be used as modifiers in a nominal construction (Christaller 1875). Like nouns, they are coordinated by noun phrase connectives **ne** (Asante, Akuapem) and **na** (Fante). As shown in Table 1 and 2, each numeral typically consists of a prefix and a stem but the form of the prefix and/or the stem may vary depending on the dialect (e.g., Fante (Fa), Akuapem (Ak), Asante (As), etc.). The dialectal differences between the forms of the numerals are largely due to dialect-specific phonological processes such as cross-height and rounding vowel harmony, consonant mutation and other assimilatory processes. However, because there is a strong mutual intelligibility between the various dialects there is no variation in the semantic content of the numerals in the language, primary or complex. In this paper, we use Fante (Fa) as the default dialect in citing examples for analysis. We will, however, attempt to point out any dialectal difference that has implication for analysis. As Akan is a tonal language, all numerals have a tonal melody which may vary across different dialects. We have not marked tones on numerals in this study because it has no direct bearing on our current analysis, although a study of tonal phonology of numerals may be justified in its own right.

There is one morphosyntactic difference between primary digital numerals and primary non-digital numerals: while digital numerals do not have alternations between singular and plural prefixes, the three non-digital bases have singular and plural prefixes (see Table 2). The atomic digits (1 – 9) take the prefix **ba-** when they refer to human nouns, e.g., **mmeranteɛ baanan** ‘four young men’, but **ba-** cannot be used with non-digital bases, e.g., **mmeranteɛ *baaha/pem** ‘int: hundred/thousand young men’.

Table 1. Akan primary digital cardinal numerals

Digital/Atoms		
	PREFIX	*STEM*
1	*ba-/bi-/ɛ-*	*ko/kor* [*e.g., ɛkor, biako* (Fa/Ak), *baako* (As)]
2	*m-/a-/e-/ba-/bi-*	*nu* [*e.g., abien* (Fa/Ak), *mmienu* (As), *baanu* (Fa/Ak/As)]
3	*m-/a-/e-/ba-*	*sa* [*e.g., ebiasa,* (Fa), *abiɛsa* (Ak), *mmiɛnsa* (As), *baasa* (As/Ak), *ebaasa* (Fa)]
4	*a-/ɛ-/ba-/n-*	*nan* [*e.g., anan* (Fa/Ak), *nnan/ɛnan* (As), *baanan* (Fa/Ak/As)]
5	*e-/ba-/n-*	*num* [*e.g., enum* (Fa/As), *nnum* (Ak/As), *baanum* (Fa/Ak/As)]
6	*n-/a-/e-/ba-*	*sia* [*e.g., asia* (Fa/Ak), *nsia* (As), *baasia* (Fa/Ak/As)]
7	*n-/a-/ba-*	*son/suon* [*e.g., asuon* (Fa), *ason* (Ak), *nson* (As), *baason* (Fa/Ak/As)]
8	*n-/a-/ba-*	*wɔtwe* [*e.g., awɔtwe* (Fa/Ak), *nwɔtwe* (As), *baawɔtwe* (Fa/Ak/As)]
9	*n-/a-/ba-*	*kron* [*e.g., akron* (Fa/Ak), *nkron* (As), *baakron* (Fa/Ak/As)]

Table 2. Akan primary non-digital/base cardinal numerals

	Non-digital/bases	
	PREFIX	*STEM*
10	*e-/a-*	*du [e.g., e-du* ‘SG/PL-ten’ (Fa), *(e-)du* ‘SG-ten’ (As/Ak), *a-du* ‘PL-ten’ (As/Ak)
100	*ɔ-/a-*	*ha* [*e.g., ɔ-ha* ‘SG-hundred’ (Fa/Ak/As), *a-ha* ‘PL-hundred’ (Fa/Ak/As)
1000	*m-/a-/ɔ-*	*pe/pem* [*e.g., a-pem* ‘SG-thousand’ (Fa/Ak/As), *m-pem* ‘PL-thousand’ (Fa/Ak/As)]

The primary numerals (except **ɔha** and **apem**) in Akan may also function as proper names given to children based on their relative order of birth or a name inherited from a family member, e.g., **Nsia** ‘name for sixth born’, **Akron/Nkroma** (also spelled Nkrumah) ‘name for a ninth born’ (see Table 3 below).

In the rest of this section, we discuss the structure and formation of Akan complex cardinal numerals. In section 4.1, we clearly set out our approach to the constructional analysis. We then discuss the various groups of complex cardinal numerals and show how they may be represented in the constructional approach.

Table 3: Akan names based on primary cardinal numerals

	NUMERAL	NAME
1	*baako/biako*	Bako
2	*mmienu/ebien*	Manu
3	*mmiɛnsa/abiasa/ebaasa*	Mɛnsa/Mansa
4	*ɛnan/anan*	Anan
5	*enum*	Anum
6	*nsia/asia*	Nsia
7	*nson/ason*	Nsonwaa
8	*nwɔtwe/awɔtwe*	Awɔtwe/Botwe
9	*nkron/akron*	Akron/Nkroma
10	*edu*	Badu

Akan complex cardinal numerals: the constructional approach

As noted above, complex cardinal numerals are formed by combining two or more primary cardinal numerals. In the following discussion we show that Akan complex cardinal numerals come in sets with shared properties and are underpinned by specific morphosyntactic and arithmetic operations. Formally, the numerals behave like regular compound and phrasal constructions in the language. Therefore, we posit constructional schemas for the common predictable properties of the groups. Given that the numerals that instantiate the schemas are fixed in form and meaning, the schemas may be construed as redundancy statements about the form and meaning of the numerals (cf. Booij 2009, 2010). The meaning – NUM(be) – of a numeral in a particular set is the numerical value of the result of the underpinning arithmetic operation. For example, multiples of *ten*, *hundred*, and *thousand* are formed by multiplication (20 = 10x2, 200 = 100x2, etc.). An example is **a-ha ebien** 'two hundred' [PL-hundred two]. However, there are no overt markers for the arithmetic operations involved in the formation of numerals below 100. For numbers greater than 100, the default marking for addition is coordination, usually with just one explicit conjunction, **na** 'and' which occurs before the last constituent, as exemplified in the numerals **ɔ-ha na anan** '(one/a) hundred and four' [lit. SG-hundred CONJ four], as shown in (2) above. Multiplication may also be marked lexically in some multiplicative numerals, where the formation of multiples of thousand are involved, e.g., **mpem ahorow mpem** 'thousands of thousands' [lit. PL-thousand various/multiples of PL-thousand] as discussed in (33) below (cf. Appah et al. 2019; Christaller 1875).

Thus, we may define constructional schemas for the two principal arithmetic operations involved in the constructions of Akan cardinal numerals – multiplication and addition. The schema for multiplication is in (12).

(12) *Multiplication schema*
⟨ $[[a]_{[+M]i}\ [b]_{j}]_k \leftrightarrow [NUM_i \times NUM_j]_k$ ⟩
(The variables *a* & *b* stand for arbitrary phonological strings, whilst *i*, *j* & *k* are indexes for the matching properties of the constituents and the numeral as a whole. NUM = arithmetical value (product) of the corresponding constituents indexed *i* and, *j*).

There is usually a member of the complex that functions as the base for the arithmetic operation. For multiplication, the bases are the non-digital primary numerals (Table 2) which, following Hurford (1975), are identified by the feature ($_{+M}$). All numerals formed by multiplication instantiate this schema, as shown in (13) for the numeral **aha ebien** '200'.

(13) ⟨ $[[a]_{[+M]i}\ [b]_{j}]_k \leftrightarrow [NUM_i \times NUM_j]_k$ ⟩
⟨ $[[aha]_{[+M]i}\ [ebien]_{j}]_k \leftrightarrow [\text{hundreds}_i \times \text{two}_j]_k$ ⟩ '200'

In the case of addition, we posit two separate schemas. The first (14) is for numerals that occur between the multiples of 10, up to 99 (11-19, 21-29, 31-39, etc.) in which there is no formal marking of addition.

(14) *Addition schema for numerals between 10 and its multiples but <100*
⟨ $[[a]_i\ [b]_j]_k \leftrightarrow [NUM_i + NUM_j]_k$ ⟩

(NUM = arithmetical value (sum) of the corresponding constituents indexed *i* and *j*)

The second schema in (15) is for numerals that are greater than 100 which optionally employ the conjunction *na* to mark addition.

(15) *Addition schema for numerals >100*
⟨ $[Num_{Ci}\ (na)\ Num_j]_{Numj} \leftrightarrow [NUM_i + NUM_j]_k$ ⟩

(NUM = the value of the corresponding Num; Num_C = numerals ≥100)

We see that the formal pole of schemas (12) and (14), to the left of the double arrow in the schemas, are similar to those for regular compounds in Akan, except the subscripted feature (cf. Appah 2013, 2015, 2016a, 2016b, 2017a, 2017b; Appah et al. 2017). Consider, for example, the general schema for noun-noun compounds in Akan and its instantiation by the compound **àsɔ́rédáń** 'church building' in (16).

(16) ⟨ $[[a]_i\ [b]_j]_{Nk} \leftrightarrow [SEM_j \text{ with relation R to } SEM_i]_j$ ⟩
$[[$*àsɔ́ré*$]_{Ni}\ [$*dáń*$]_{Nj}]_{Nk}$ 'church building'
[*àsɔ́ré*] 'church' [*dáń*] 'building' (cf. Appah 2017a: 143)

We see that the formal pole at the highest level is very much like the formal pole of the schema in (14). In the same way, schema (15) is like the schema for coordinate constructions (cf. Appah et al. 2019). Thus, these schemas are instantiations of the respective compounds and coordinate constructions in Akan, supporting our view that in terms of form, numeral constructions are not particularly different from other morphological and syntactic constructions in the language. This point will be illustrated further below.

Groups of Akan complex cardinal numerals

We now discuss the various groups of Akan complex cardinal numerals. We will begin with numerals in which two or three primary numerals are juxtaposed to form the complex numeral. The numerals are, therefore, compounds (Christaller 1875; Ofori 2008) and are subject to all the phonological processes that operate within compounds (cf. Dolphyne 1988; Marfo 2004; Abakah 2004; Ofori 2008). Being compounds means that they are words which should exhibit evidence of lexical integrity and the most convincing sign of lexical integrity in Akan numerals is that their immediate constituents cannot be interrupted by any extraneous material – lexical or syntactic. Thus, whatever occurs inside a numeral in this group must itself be a numeral and an immediate constituent of the complex numeral or be embedded in an immediate constituent of the numeral. This is consistent with the condition that the sister of a numeral must be a numeral (Hurford 1975, 1987, 2007). See (8) and (9) above. For practical reasons, we have to begin with a discussion of the formation of the multiples of the base numeral, up to 90.

Multiples of ten (20-90)

To be able to put the discussion of the formation of numerals whose value is less than one hundred in proper perspective, we need to clarify the formation of the multiples of the base *ten* from *twenty* to *ninety*, which are presented in Table 4. They are formed by compounding a digital numeral and the plural of the base **du** ‘ten’, where plurality is marked by the prefix *e-* (as in **e-du** [PL-ten]).

Table 4: Akan numeral – 20-90

	Numeral
20	*edu-o-nu*
30	*edu-a-sa*
40	*edu-a-nan*
50	*edu-o-num*
60	*edu-o-sia*
70	*edu-o-suon*
80	*edu-ɔ-wɔtwe*
90	*edu-ɔ-kron*

The relatively simple structure of these numerals is consistent with Greenberg's (1978) observation that multiples of the base of a numeral system, like '70', in a decimal system, are less marked than other comparably high numbers, like '71'.

An interesting formal feature of these numerals is the appearance of what looks like an interfix, a stem extender (SE), that occurs between the decimal base and the digital numeral on the right. The SE is realized as a mid-back vowel that agrees in tongue root position and/or rounding harmony with the vowel of the digital numeral (see Ofori 2008 for a discussion of the phonological rules that derive SE). The only unrounded vowel that occurs as a SE in these numerals is the vowel [a] which occurs in the numerals **eduasa** '30' and **eduanan** '40'. Its presence can be explained by the fact that this vowel occurs freely with both advanced and lax vowels, as well as rounded and unrounded vowels in Akan (cf. Dolphyne 1988).

The general properties of the set of multiples of ten in Table 4 are captured in the constructional schema in (17), which states that the meaning of a multiple of '10' is the product of the numerical value of a digital numeral and the value of the pre-specified base **e-du** 'PL-10'. Thus, the arithmetic operation involved in the interpretation of these numerals is multiplication, as shown on the right of the double arrow, so that schema (17) instantiates the multiplication schemas in (12), where there is no overt marking of multiplication in the formal realization. The instantiating schema in (18) is for '20'.

(17) *Schema for numerals 20-90*

$\langle\ [[\textit{e-du}]_{i}\ \text{-SE-}\ [\textit{b}]_{j\ [dig]}\ ]_{k} \leftrightarrow [10_{i}\ \text{x NUM}_{j}]_{k}\ \rangle$

(18) *Schema for numerals 20-90*

$\langle\ [[\textit{e-du}]_{i}\ \text{-SE-}\ [\textit{b}]_{j\ [dig]}\ ]_{k} \leftrightarrow [10_{i}\ \text{x NUM}_{j}]_{k}\ \rangle$

$\langle\ [[\textit{e-du}]_{i}\ \text{-o-}\ [\textit{nu}]_{j\ [dig]}\ ]_{k} \leftrightarrow [10_{i}\ \text{x}\ 2_{j}]_{k}\ \rangle$ '20'

Having settled the structure of the multiples of '10', up to 90 in Akan, we can now discuss the structure of numerals that occur between *ten* and multiples of *ten*, such as 11-19 and 21-29 – 90-99.

Between decades (11-19)

The first set of numerals that occur between the decades are numerals from 'eleven' to 'nineteen' (11-19). They are formed by compounding the base **du** 'ten' with the digital numerals (see Table 5).

Table 5: Akan complex numerals – 11-19

	Numeral
11	*du-biako* 'ten-one'
12	*du-ebien* 'ten-two'
13	*du-ebiasa* 'ten-three'
14	*du-anan* 'ten-four'
15	*du-enum* 'ten-five'
16	*du-esia* 'ten-six'
17	*du-esuon* 'ten-seven'
18	*du-awɔtwe* 'ten-eight'
19	*du-akron* 'ten-nine'

We assume that the numerals in this group instantiate the constructional schema in (19) which also instantiate the schema in (14). The indices (*i, j,* & *k*) identify forms and corresponding meanings of numerals. The feature $[_{\text{dig}}]$ denotes the set of digital numerals 1-9. That is, the numerals are formed by adding a digital numeral to a base, which also happens to be the fundamental base (Greenberg 1978), given that the Akan numeral system is decimal.

(19) *Schema for numerals 11-19*
$\langle [[du]_i\ [b]_{[\text{dig}]j}]_k \leftrightarrow [10_i + \text{NUM}_j]_k \rangle$

Schema (19) is a constructional idiom, a constructional schema with the first element pre-specified as **du** '10' (cf. Jackendoff 2002), which states that the meaning of a numeral within the range 11-19 is the sum of the numerical value of a digital numeral and the value of the pre-specified base **du** 'ten'. Thus, the arithmetic operation involved in the interpretation of this class of numerals is addition, as shown in the semantic poles to the right of the double arrow. But there is no overt marker of addition in the formal pole, to the left of the double arrow. Thus, one might be tempted to suggest that the formal process of compounding marks the addition of the numerical value of the constituents. However, numerals which are formed by multiplication may also surface as compounds, so there is no intrinsic link between the arithmetic operation of addition and the formal operation of compounding. In terms of the linear order of constituents, the higher number (**du**, in this case) occurs first and then the digit. This is consistent with observations about the occurrence of modifiers in Akan (Saah 2004) as well as the packing strategy (Hurford 2007). That is, the lower value numeral serves as a modifier to the meaning of the higher value numeral.

Between decades (21-29 – 91-99)

Like numerals within the range 11 to 19, all numerals ranging between the multiples of 10, like 21-29, 31-39, etc., up to 91-99 are formed by compounding a base which is a multiple of ten, from 20 to 90 (Table 4), and a digital numeral (Table 1) and they instantiate a schema like the one in (19). We shall illustrate the group with the numeral that occur between 20 and 30, as shown un (20).

(20) *Numerals ranging from 21-29*

eduonu biako	'21'	**eduonu anan**	'24'	**eduonu esuon**	'27'
eduonu ebien	'22'	**eduonu enum**	'25'	**eduonu awɔtwe**	'28'
eduonu ebiasa	'23'	**eduonu esia**	'26'	**eduonu akron**	'29'

We may call these the *twenty-n constructions* and represent them by the schema in (21) which instantiates a higher constructional schema, ⟨ [[PL-ten]-*n*] ↔ [PL-ten + n, 0<n<10] ⟩ with a constraint that *n* be digital. The structure of this class of numerals is consistent with the observation by Comrie (2011) that numeral expressions are constructed according to the pattern ... $xn + y$. That is, some numeral x multiplied by the base plus some other numeral [y].

(21) *twenty-n construction*
⟨ [eduonu-n] ↔ [20 + n, 0<n<10] ⟩

Schema (21) is a complex one that results from a conflation of two schemas. The fully specified schema is in (22). It inherits its structure from two separate schemas, an addition schema which builds on an existing multiplication schema like (17) for the base numeral, which is a multiple-of-ten, through the process of template unification (Booij 2007), as shown in (23).

1

(22) *Schema for numerals 21-29*
$\langle\, [[du\ [a]_{i\,[\mathrm{dig}]}]_j\ [b]_{k\,[\mathrm{dig}]}]_q \leftrightarrow [[10 \times \mathrm{NUM}_i]_j + \mathrm{NUM}_k]_q \,\rangle$

(23) $\langle\, [du\ [a]_{i\,[\mathrm{dig}]}]_j \leftrightarrow [10 \times \mathrm{NUM}_\mathrm{i}]_\mathrm{j} \,\rangle$ $\qquad$ $\langle\, [du\ [b]_{k\,[\mathrm{dig}]}\ ]_q \leftrightarrow [10 + \mathrm{NUM}_k]_q \,\rangle$

$\langle\, [[du\ [a]_{i\,[\mathrm{dig}]}]_j\ [b]_{k\,[\mathrm{dig}]}]_q \leftrightarrow [[10 \times \mathrm{NUM}_i]_j + \mathrm{NUM}_k]_q \,\rangle$

The idea of template unification is consistent with the observation that "by allowing inheritance to hold of constituents internal to particular constructions we can capture generalizations about the internal structure of constructions. By allowing multiple inheritance we account for instances which appear to be simultaneously motivated by two distinct constructions" (Goldberg 1995: 100).

Multiples of hundred (200-900)

Multiples of hundred (200–900), as presented in (24), are formed by compounding the base **aha** (the plural of **ɔha** 'hundred') and a digital numeral (cf. Ofori 2008; Christaller 1875), and their general properties are captured in the schema in (26), which is a constructional idiom with the form **a-ha** 'PL-hundred' pre-specified. A primary/complex numeral *n* (0<*n*<100) may be coordinated to the compound as an addend, as shown in (25).

(24)	**ahaenu/ahaebien**	'two hundred'	**ahaesia**	'six hundred'
	ahaasa/ahaebiasa	'three hundred'	**ahaesuon**	'seven hundred'
	ahaanan	'four hundred'	**ahaawɔtwe**	'eight hundred'
	ahaenum	'five hundred'	**ahaakron**	'nine hundred'

(25)	**ahaenu/ahaebien na ebien**	'two hundred and two'
	ahaesia na asuon	'six hundred and seven'
	ahaasa/ahaebiasa na du-biako	'three hundred and eleven'
	ahaesuon na eduonu anan	'seven hundred and twenty-four'

(26) *Schema for multiples of hundred 200-900*
$\langle [aha\ [a]_{[\mathrm{dig}]i}]_j \leftrightarrow [100 \text{ x } \mathrm{NUM}_i]_j \rangle$

Again, as noted above, the largely uncomplicated structure of the multiples of 100 numerals is consistent with the observation that the multiples of a base of a numeral system are less marked than comparably high numerals.

Multiples of thousand

Multiples of thousand (*thousands*) are formed in three principal ways with interesting properties and uses. There are three different subtypes, which are discussed below.
Multiples of thousand (2000-9000)

The first means of forming multiples of thousand is by compounding **mpem** (plural of **apem** 'thousand'), with the digital numerals 1-9, as shown in (27), and their general properties captured in the constructional schema in (28), which is a constructional idiom in which **m-pem** [PL-thousand] is pre-specified. A fully specified schema exemplifying *mpem enum* '5000' is found in (29).

(27)	**mpem ebien**	'two thousand'	**mpem esia**	'six thousand'
	mpem ebiasa	'three thousand'	**mpem esuon**	'seven thousand'
	mpem anan	'four thousand'	**mpem awɔtwe**	'eight thousand'
	mpem enum	'five thousand'	**mpem akron**	'nine thousand'

(28) *Schema for multiples of thousand 2000-9000*
$\langle [mpem\ [a]_{[\mathrm{dig}]i}]_j \leftrightarrow [1000 \text{ x } \mathrm{NUM}_i]_j \rangle$

(29) $\langle [mpem\ [enum]_{[\mathrm{dig}]i}]_j \leftrightarrow [1000 \text{ x } 5_i]_j \rangle$ '5000'

Mpemdu 'ten thousand', also realized as **ɔpedu**, has a similar structure but the multiplier is not digital. Indeed, numerals up to one million minus one (1,000,000-1), which are formed by multiplication and are multiples of the base **apem** 'thousand', instantiate the schema in (28). Given this, we can revise schema (28), generalizing it by taking away the constraining feature [$_{\mathrm{dig}}$] of the multiplier and introducing a constraint in the semantic pole on the right of the double arrow that requires that the multiplier be greater than 1 and less than 1000, as shown in (30).

(30) *Schema for multiples of thousand numerals up to 999000*
⟨ [*mpem* [*a*]$_i$]$_j$ ↔ [1000 x NUM$_{[1 < x < 1000]i}$]$_j$ ⟩

The appended constraining feature ($_{[1 < x < 1000]}$) is needed because, as will be shown in (33) below, the expression **mpem mpem** does not necessarily refer to the product of 1000 multiplied by 1000 (i.e., 1 million). Rather it is a multiplicative numeral which refers to an indefinite number of "thousands" (Appah et al. 2019; Christaller 1875). One million is formed by compounding **ɔpe** and **apem**, as in **ɔpepem** or by reduplicating **ɔpe**, as in **ɔpepe**. See discussion of **ɔpe** below.

Multiples of thousand in multiples of ten (20,000-900,000)

The second group of multiples of thousand, as the examples in (31) show, are formed by compounding **ɔpe** with multiples of 10 (Table 4) and 100, as in (24).

(31)

ɔpeduonu	'twenty thousand'	**ɔpeduosia**	'sixty thousand'
ɔpeduasa	'thirty thousand'	**ɔpeduoson**	'seventy thousand'
ɔpeduanan	'forty thousand'	**ɔpeduowɔtwe**	'eighty thousand'
ɔpeduonum	'fifty thousand'	**ɔpeduokron**	'ninety thousand'
ɔpehanu	'200,000'	**ɔpehasa**	'300,000'
ɔpehannan	'400,000	**ɔpehanum**	'500,000

All the examples in this group are from the Akuapem dialect, as reported in Christaller (1875) and their properties are captured by schema (32), which states that **ɔpe** is multiplied by a multiple of the base. This renders the constraining feature $_{[\text{Non-dig}]}$ superfluous because, as noted above, the Akan numeral system is decimal which makes the base non-digital. However, we maintain it to distinguish the numerals in (31) from those in (27), which have both digital and non-digital multiplicands.

(32) ⟨ [*ɔpe* [*a*]$_{[+M, \text{Non-dig}]i}$]$_j$ ↔ [1000 x NUM$_i$]$_j$ ⟩

Multiples of thousand (million and above)

The third group of multiples of thousand looks very much like the second, discussed in 0, but the numerals may be formed by just reduplicating **mpem/ɔpe** or the reduplication plus words that express multiplicity (or infinite number) of some referent such as **ahorow** 'various' (Appah et al. 2019; Christaller 1875). See the data in (33).

(33)

ɔpepeto	'millions'
ɔpepepem	'thousand millions/a milliard'
mpem-mpem	'thousands'
mpem ahorow mpem	'thousands of thousands'
ɔpehuhaa/mpem mpem huha	'many thousands/myriads'

It is clear from the numerals in (31) and (33) that, unlike the other multiples of thousand, these groups do not admit singular **apem** 'thousand'. Even plural **mpem** occurs only minimally. Rather, the root of thousand **pem** is truncated, realized simply as **pe**, and is prefixed with **ɔ-** to form **ɔpe** which serves as the multiplicand and is compounded with another numeral (the multiplier) or a word that refers to an indefinite number, including **tó** 'empty (as of a container)'. We believe that the prefix **ɔ-**, which marks abstract nouns elsewhere in the grammar (as in **ɔ-ko** 'a war'), helps in conveying the potentially unbounded nature of the numerals formed based on **ɔpe**.

It can be argued that this pattern of *thousands* formation lexicalizes the general meaning of thousand in **ɔpe**. However, the sense of multiplicity, which is ordinarily expressed by the plural form **mpem** in other multiples-of-thousand (0), is passed on to the numeral which follows **ɔpe** or any measure word, for that matter, which follows it (cf. Appah et al. 2019). The distributional difference between **mpem** and **ɔpe** leads us to consider them as allomorphic variants where, in addition to the formal differences, the **ɔpe** variant is underspecified for the feature [MULTI]plicity. Thus, we find, for instance, that even when the right constituent is not a numeral, it still has the responsibility of expressing multiplicity as far as an **ɔpe**-based multiple of thousand is concerned.

Naturally, it would be expected that whatever occurs as the second element (numeral or not) would have the capacity to bear the sense of multiplicity. Hence, it is not possible for digital numerals (1-9) to occur with **ɔpe**, but the non-numeral **ahorow** 'different kinds/various' does occur with **ɔpe**, as in (33), because it inherently expresses multiplicity. The use of **tó** [t^hó] 'empty (as of a container)' is a bit of a puzzle, but it can be explained if we consider the fact that an empty container is available to be filled by any quantity that would occupy the available space. But, because the size or volume of the "empty container" is not indicated, its capacity can be construed with an elastic tinge (Appah et al. 2019).

We observe from the foregoing that Akan has two principal strategies for forming multiples of thousand both of which inherit some properties from **apem** 'thousand'. In one, **apem** is pluralized and compounded with a multiplier, which can be any number up to '999'. In the other, an allomorphic variant of **apem** (**ɔpe**) lexicalizes the general meaning 'thousand' but the sense of multiplicity is left for the multiplier to express, and the multiplier cannot be digital, if it is a numeral. But it can also be any form that expresses potentially indefinite quantity. Hence, Christaller (1875: 51) observes that this formula is used for expressing an indefinite number of thousands and millions.

We can account for these observations in the constructionist framework by positing schemas and sub-schemas to account for the regularities and sub-regularities in *thousands* formation. We assume a constructional schema with two sub-schemas, one each for the two patterns, with their associated meaning specifications forming a hierarchy of types. Each sub-schema is a constructional idiom in which a specific realization of the word for thousand is pre-specified, as shown in (34).

(34) ⟨ [APEM [*a*]$_i$]$_j$ ↔ [1000 x NUM$_i$]$_j$ ⟩

[*mpem* [*a*]$_i$]$_j$ [*ɔpe* [*a*]$_{[\text{Non-dig}]i}$]$_j$

The difference between these two sub-patterns is underscored by the fact that one may participate in some further derivation where the other is either totally excluded or rarely used. As the discussion of examples (31) and (33) shows, it is the constructional idiom [*ɔpe* [x]$_{[\text{Non-dig}]i}$]$_j$ that is employed for the expression of numerals, equal to or greater than one million. On the other hand, **ɔpe** never seems to occur as a base for numerals below *ten thousand*. We may argue, therefore, that reduplicated **ɔpe** (**ɔpepe**) has grammaticalized (or is grammaticalizing) into a form for 'million', being currently employed for expressing any numerical value construed as multiples of million. It is this 'million' sense of **ɔpepe** that can be multiplied by the digital numerals from '2' to '9' in forming multiples of millions up to nine million, as shown in (35).

(35)	**ɔpepe**	'1 million'	**ɔpepensa**	'3 million'
	ɔpepennu	'2 million'	**ɔpepemnan**	'4 million'

(Christaller 1875: 51)

Also, all instances of millions and their multiples, including billions, cited by Christaller (1875), have reduplicated **ɔpepe** as base, as shown in (36).

(36)	**ɔpepe-du**	'ten millions'
	ɔpepeha	'hundred millions'
	ɔpepepem	'thousand millions, a milliard'
	ɔpepepepem	'a billion'

(Christaller 1875: 51)

Finally, when **ɔpepe** is (re-)reduplicated (e.g., **ɔpepepeepee**) it is used for huge numbers of millions, including billions and trillions (sometimes with socio-political slant).[3]

Summary and conclusion

In this paper, we have discussed the construction of Akan complex cardinal numerals, showing that they fall into well-defined groups whose interpretation is mediated by specific arithmetic operations. The basic facts about Akan primary and complex cardinal numerals and the arithmetic operations underpinning their interpretation are summarized in Table 6. It shows that:

[3] In contemporary Ghanaian political discourse, the (re-*)reduplicated form of *ɔpe* 'million' is employed in the ever-present blame-game between politician, where a new government attempts to show how much a predecessor government has borrowed and/or misappropriated, with the magnitude of the amount involved, correlating with the number of times the stem *pe* is reduplicated, as in *ɔpepepeepeepeepee*.

i. Akan has twelve primary numerals – 1-10, 100 and 1000 (Table 1 and 2). All others are complex numerals formed from the twelve primary numerals.
ii. Complex numerals come in the form of compounds or coordinate constructions.
iii. Two arithmetic operations (addition & multiplication) underpin the formation/interpretation of Akan complex cardinal numerals.
iv. The arithmetic operations apply to the formation of well-defined groups of numerals; 11-19 are constructed exclusively through addition (Table 5), multiples of ten (20-90) through multiplication (Table 4), etc.

Table 6. Summary of arithmetic operation and examples of cardinal numerals

Numeral range	**Means of expression**	**Arithmetic operation**	**Example**	
			Number	**Expression**
Primary forms				
1–10, 100, 1000			5	*enum*
Complex forms				
11–19	(PL-)ten + NUM$_{[dig]}$	Addition	15	*duenum*
tens: 20–90	PL-ten x NUM$_{[dig]}$	Multiplication	50	*eduonum*
Between *tens* 21–29, ... 91–99	PL-tens + NUM$_{[dig]}$	Addition	55	*eduenum enum*
Hundreds: 200–900	PL-hundred x NUM$_{[dig]}$	Multiplication	500	*ahaenum*
Thousands: 2000–9000	PL-thousand+NUM$_{[dig]}$	Multiplication	5000	*mpemenum*
tens of thousands 10,000–	• PL-thousand x tens • *ɔpe* + NUM$_{[Nod-dig]}$	Multiplication	50,000	*mpemeduonum*
Million	COMP: *ɔpe* + *apem*	Multiplication	1,000,000	*ɔpepem*
Millions/billions	COMP: *ɔpepe* - (...)	multiplication	Thousands/millions /billions	*ɔpepepeepee*

In this paper, we have attempted to situate our observations in the context of the current state of research on numerals. We find that our observations are generally consistent with what has been found in the literature, although the interpretation of the observed facts differ, depending on the theoretical assumptions underpinning the study. We have shown that Akan complex cardinal numerals share structures with other constructions in the language. Therefore, structurally, they do not differ radically from other constructions in the language. However, they exhibit unique formal and semantic properties that portray them as pairings of particular forms and particular meanings. Thus, we analysed them as constructions and posited constructional schemas to account for individual groups, capturing the common properties of the groups. This study, therefore, has shown how the formation of cardinal numerals, which straddles morphology and syntax may be accounted for straightforwardly in a constructionist framework. An interesting observation we make, which may be studied further, is the lexicalization of the form **ɔpe** for the expression for multiples of thousands in Akan.

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