Rarities in numeral systems

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1 Introduction

The paper surveys rarities in numeral systems across the world. Space permits us only to look at the most conspicuous kinds of rarities that are featured in the vast set of languages in the world. The study aims at a high level of preciseness as to what counts as a numeral and what counts as rare, and doubtful cases will be treated pre-emptively in footnotes.

2 Numerals

2.1 What are numerals?

In this paper, we define numerals as:

1. *spoken*
2. *normed expressions* that are used to denote the
3. *exact number* of objects for an
4. *open class of objects* in an
5. *open class of social situations* with
6. *the whole speech community* in question.

With the first point we mean to disregard symbol combination systems, e. g., Roman numerals, that are confined to written communication (but, of course, essentially all of our primary data come from written representations of the spoken language).

The second point serves to exclude expressions that also denote exact numbers, but are not the normal or neutral way to say those numbers, e. g., 'eight-times-nine-and-another-two' for the normal 'seventy-four', but also to demarcate the area where the numeral system ends, which is, when there aren't any normed expressions.

As for the third point, languages usually have a rich set of expressions for inexact quantities, 'a lot', 'few', 'really many', 'about fifty' (but hardly *'about fifty-one') that have relatively high frequency in discourse. These are interesting in themselves but will not be included here because of their different fuzzy nature compared to exact number expressions.

Concerning the fourth point, some languages have special counting systems for a restricted class of objects (e. g. in Wuvulu (Hafford 1999: 37–39) for counting coconuts). These can be quite idiosyncratic and since all languages which have exact enumeration must have a means for counting an open class of objects, it is preferable to study that, as it corresponds to a general kind of communicative need of a society.

The reason for the fifth point, the requirement on social situations, is to take a stand on so-called body-tally systems (cf. Lean 1992: 2.4–2.6). A body-tally-system may be defined as follows. Assume a sequence of body parts beginning with the fingers of one hand continuing with some points along the lower and upper arm, reaching one or more points of the head, then ending with the corresponding body-parts on the opposite arm and finally hand. A number *n* is then denoted by the *n*th body-part-term in the sequence, e. g., 'nose' or 'elbow on the other side'. There are features that distinguish body-tally systems from other counting systems with etymologies from body parts. Non-body-tally systems use only fingers, toes, hands, occasionally eye and head, whereas body-tally systems always use some intermediate points, such as elbow, shoulder or nose, and let them form a sequential order from one side of the body to the other. Typically, body-tally systems are only used in special circumstances, such as bridal price negotiations, and in other cases you would use a different numeral system or not use exact enumeration at all. The information on the social status of the body-tally numeral systems is very incomplete; We can say that for the vast majority we do not have such information, but for those in which we do, the social situation restriction applies. Body-tallying has to be done on a physically present person and to understand what number is referred to the process must be watched, so, for instance, body-tallying numerals would be infelicitous when it is dark. For instance, de Vries (1998) found that body-tally numerals in a Bible translation could not be understood, i. e., were often mis-translated back to Indonesian by bilingual persons. Of course, there could be some other language(s), unknown to us at present, where body-tally numerals can be used in a fully open class of social situations; such a body-tally system would accordingly be included in the study. Body-tally systems are attested in abundance in Papua New

Guinea and Indonesian Papua, in a geographically continuous area centered at the Ok family and, even if in decline, are still used today. Although many writers have neglected to mention it, there are also indisputable attestations of long extinct body-tally systems from Kulin (Pama-Nyungan, Australia) varieties in southeast Australia (Howitt 1889: 317–318, Howitt 1904: 697–703).

Finally, regarding the sixth point, we are not interested in numeral systems which are particular to some small subsets of the speakers of the language in question (e. g., professional mathematicians) because such systems might not respond to the conditions and needs of the majority of a society.

Numerals provide a good testing bed for patterns across languages given their comparatively clear semantics and modularity. As to numeral semantics, languages may differ as to which quantificational meanings they express / lexicalize, notably in approximate numeration and whether a counted set of objects constitute a group or not, but these matters are minor compared to differences languages show, e. g., in verbal tense / aspect. Likewise, although not universally, numerals tend to have uniform, clearly identifiable, syntactic behaviour within a language. Also, if two languages have exact numeration for a certain range of numbers, one expects the two to give a similar functional load to these expressions, excluding possibilities such as numbers also being used for, say, colours or as metaphors significantly wider in one language or the other. This appears sound also in the light of the only corpus study of numeral frequencies in a language with a restricted numeral system – McGregor (2004: 204) – which shows that 'one' and 'two' in Gooniyandi (Bunaban, Australia) occur with comparable frequency to 'one' and 'two' in English.

2.2 Rareness

In this paper we present cases that are rare, either in that (a) they are present in few languages or in that (b) they are present in few geographical spheres. Most cases are of the (a)-kind, but for example, base-12 systems in northern Nigeria are present in relatively many languages, from several different families, but are confined to just this geographical sphere, so they are counted as rare in the sense of (b) only. Geographically separate instances are likely to be independent, and the bottom line is that we are interested in rare independent innovations – whether or not they have grown genetically or areally onto many languages.

2.3 Survey

Lots of data is available in one form or another for numerals. It seems that numerals together with pronouns, kinship terms, body part terms, and other basic vocabulary (sun, water, etc), and perhaps "sketchy" phonological inventory, are the parts of language where there exists empirical data for a really large subset of the world's known languages. One may legitimately ask just how large this subset is when it comes to numerals – for how many languages do we have data on numerals? Let's say we count about 7,000 attested native spoken languages for the world. A definite lower bound is 3,880, since we can produce a list of references to numeral data from 3,880 definitely distinct languages. An upper bound is harder to give. We entertain the rather time-consuming methodology of trying to obtain every first-hand descriptive data reference found in any handbook or relevant publication whatsoever. The survey in this paper is based on the data we have collected so far. We currently have about 13,500 references, some describing numeral systems of many languages in the same publication, and, with 7,000 languages in the world, many different publications describe the same language. (The fact that often there is more than one independent source for one and the same language helps us to determine the accuracy.) It is impossible at this point to say how many languages the sources account for since they attest dialectal varieties, varieties from the same location but different centuries, partial data, data of varying quality, duplicated data, etc. However, at least one language from every attested language family or isolate is included in the survey (if numeral data is at all attested for the family in question).

In addition to first hand sources, we have also drawn inspiration from the rich existing literature on numerals in general. The subject, in fact, goes back more than 200 years in time — the first major work being the remarkable *Aritmetica Delle Nazioni* by Hervás y Panduro (1786). Since then, our bibliography counts some 20 doctoral dissertations, over 100 further monographs and more than 700 articles to have appeared. These range from purely descriptive accounts to areal, comparative-historical, typological, and deep syntactic studies — solely devoted to spoken language numerals as defined above. (The literature on written symbol systems for mathematics is even more voluminous.) However, since most of the literature just re-hashes the same data, the recourse to first-hand sources is essential in order to understand the true diversity in numerals in the world's languages.

3 Rarities

3.1 Rare bases

Perhaps the most salient single characteristic of a numeral system is its base, or more correctly speaking, its set of bases. The *set of bases* of a natural language numeral system may be defined as follows.

The number n is a base iff

1. the next higher base (or the end of the normed expressions) is a multiple of n; and
2. a proper majority of the expressions for numbers between n and the next higher base are formed by (a single) addition or subtraction of n or a multiple of n with expressions for numbers smaller than n.

This assumes that, for any expression, the linguist can unambiguously analyze each numeral expression into its constituent parts (or analyze it as consisting of only one part). As an example, for Swedish we would begin by finding the biggest part of the highest normed expression, which according to our own knowledge is *miljard* (10^9). Thereafter we can find the next lower base by trying divisors x of 10^9 to see if the numbers between x and 10^9 are expressed in the required form. For example, $x = 5 \cdot 10^8$ is not, because we do not say **en-halv-miljard plus ett* (*half-a-billion plus one) or the like for $5 \cdot 10^8 + 1$ or any, let alone a majority, of the numbers between $5 \cdot 10^8$ and 10^9. However, 'miljon' (10^6) fulfils the requirements, and, continuing with the same analysis for lower and lower numbers, we arrive at the conclusion that Swedish has $\{10, 10^2, 10^3, 10^6, 10^9\}$ as its set of bases.

The definition of base as stated gives unambiguous decisions for formations which are sometimes (and sometimes not) called base by other authors; systematic subtractions, special lexemes for base-multiples, or isolated cases of addition, e. g., only $7 = 6 + 1$ but otherwise no additions involving 6. Examples of such cases and their systematic resolution with our definition are given in Table 1 on the following page. It is important here to note that there doesn't have to be a monomorphemic word for something that is a base. In the case of Kare, at least if we assume that the numbers above 20 are formed parallel to 30, then 20 is a base. Further, 10 or 15 are not bases even though the words for them are monomorphemic — the definition interprets them as special words for multiples of 5, just like some base-10 systems have monomorphemic words for 20, 30, ..., 90.

Table 1. Examples of formation types and outcomes of the definition of base (see text).

	Lutuami Klamath-Modoc, USA (Dixon and Kroeber 1907: 673)		**Nyokon** Bantoid / Atlantic-Congo, Cameroon (Richardson 1957: 30)		**Kare** Bantu / Atlantic-Congo, Sudan (Dijkmans 1974: 147)		**Ainu** Isolate, Japan (Refsing 1986: 110)	
	Analysis	Expression	Analysis	Expression	Analysis	Expression	Analysis	Expression
1	1	nas	1	ámɔ̀	1	emotí	1	sine
2	2	lap	2	àfɔ́ɔ̀	2	ibili	2	tu
3	3	ndan	3	átár	3	etotu	3	re
4	4	umit	4	ɲnn̩s	4	biu	4	ine
5	5	tunip	5	ɟtɔ́ɔ̀r	5	etano	5	asikne
6	5+1	nas-ksapt	6	átʃɲ́n	5+1	etano na emoti	10-4	iwan
7	5+2	lap-ksapt	6+1	ɟtʃɲ́n námɔ̀	5+2	etano na ibili	10-3	arwan
8	5+3	ndan-ksapt	?	ɟyáá n̩ màn	5+3	etano na etotu	10-2	tupesan
9	10-1	nas-xept	8+1	ɟyáá n̩ màn námɔ̀	5+4	etano na bînu	10-1	sinepesan
10	10	te-unip	10	àwát	10	la-ato	10	wan
11	10+1	taunep-anta nas	10+1	àwát ámɔ̀	10+1	laäto na emoti	10+1	sine ikasma wan
…	…	…	…	…	…	…	…	…
15	…	…	…	…	15	sanga		
16	…	…	…	…	15+1	sanga-na-emoti		
…	…	…	…	…	…	…		
20	2x10	lap-eni taunep	20	n̩tʃɲ́n	2x10	atumbili	20	hot
21	2x10+1	lap-eni taunep-anta nas	20+1	n̩tʃɲ́n ámɔ̀	…	…	20+1	sine ikasma hot
…	…	…	…	…	…	…	…	…
30	3x10	nda-ni taunep	3x10	àwát átár	2x10+10	atumbili na laato	20+10	wan e tu hot
…	…	…	…	…	…	…	…	…
40	…	…	…	…	…	…	2x20	tu hot
Base		**5-10**		**10**		**5-20**		**5-10-20**

The expression 'base-x system' will be used to mean that 'x is in the set of bases' for the numeral system in question. Similarly, 'base-x_1-…-x_n' system will mean that all of x_i is in the set of bases, without any commitment that the $x_1, \ldots, x_n$ exhaust the set of bases.

3.1.1 No base

There are a number of languages for which there is an explicit statement in the descriptive literature that they lack (exact) numerals above one.

Nadëb (Nadahup, Brazil):

According to Weir (1984: 103–104), the words for 2 and 3 are inexact. The vocabulary of a closely related variety lists completely different words for 1–3 (Schultz 1959) and the study by Münzel (1972) lacks information on numerals (cf. Epps 2006: 263). We have not seen the wordlist collected by Natterer (Koch-Grünberg 1906: 881), though this might not include numerals anyway.

Pre-contact Jarawara (Arawán, Brazil):

According to Dixon (2004: 559) and indeed the only other published wordlists for Jarawara (and closely related varieties) show some overlap between forms for 2, 3, 'few' and 'many' (Anonby and Anonby 2007: 25).

Pre-contact Yuqui (Tupi-Guaraní/Tupí, Bolivia):

According to Villafañe (2003: 68). As far as we are aware, there are no other published descriptions of this language that include the numerals.

Canela-Krahô (Jê/Jê-Jabutí, Brazil):

According to Green (1997: 181). However, an early vocabulary shows a restricted system (Kissenberth 1912: 54).

Krenák (Aimoré, Brazil):

According to a synthesis of earlier data by Loukotka (1955: 125–126) which follows observations such as Renault (1903: 1111). Even if there were no normed oral expressions, small numbers could be communicated using fingers on the hand (Ehrenreich 1887: 41–46).

Parintintin (Tupí-Guaraní / Tupí, Brazil):

According to Nimuendajú (1924: 240–241). Indeed, the larger dictionary by Betts (1981) agrees that the word frequently glossed as 'two' (cf. Sampaio 1997: 57–58) actually has an inexact meaning.

Wari' (Chapacura-Wanham, Brazil):

According to one vocabulary collected by Hanke (1956). A later, more extensive, description of a variety in the same dialect cluster does show a word for 'two' albeit glossed literally as 'facing each other'(Everett and Kern 1997: 452–459). An attempt at documentation of the most closely related language, the moribund Oro Win, failed to uncover any number words (Popky 1999: 38).

Chiquitano (Isolate, Bolivia):

According to Adam and Henry (1880: 19) which is corroborated by d'Orbigny (1839: 163) and Clark (1937: 118–119,138) and several later attestations of Chiquitano dialects show Spanish (Nordenskiöld 1911: 232, Nordenskiöld n.d.; Tormo 1993: 15, 108) or Portuguese (Santana 2005: 94) loans for 'two' and above. However, there are also dialects where a native term for 'two' is attested (Montaño Aragón 1989: 335–400).

"All" Campa and Machigenga groups (Pre-Andine / Arawak, Peru):

According to Wise and Riggle (1979: 88). As far as we are aware, published vocabularies (too many to list) show little indication that the words given for 'two' (and sometimes above) are in reality inexact. However, Wise and Riggle (1979) did work with basic mathematics education among these groups and therefore their judgement is arguably deeper.

Culina (Arawán, Peru):

According to Wise and Riggle (1979: 88). Unfortunately, we have not had access to other materials on either Brazilian or Peruvian Culina to double check the claim.

Arabela (Zaparoan, Peru):

According to Wise and Riggle (1979: 88), although the later, quite extensive dictionary of Rich (1999) does show distinct expressions for 'two' and 'three'. Possibly, Wise and Riggle (1979) who did work with basic mathematics education looked at these expressions and their meaning more closely.

Achuar (Jivaroan, Ecuador):

According to Wise and Riggle (1979: 88), though later more extensive descriptions show expressions for 'two' and higher numerals (Fast and Fast 1981: 58–59; Fast et al. 1996). It is possible that expressions for 'two' and higher numerals crystallized as a result of increased contact with a counting culture (Gnerre 1986) or even reflects normative rather than descriptive usage. Therefore, Wise and Riggle (1979) who did work with basic mathematics, could very well be descriptively more accurate for the traditional state of the language.

Fuyuge (Goilalan, Papua New Guinea):

One early description of Fuyuge says that the 'two' word is also used for a small number (Ray 1912: 313–314). However, there is a word listed as 'three' but no explicit statement to the fact that this, like 'two', also has an inexact meaning. A very small vocabulary, probably collected by the same person lists 1, 2, $2+1$ and no further comments (Fastre 1920: 116), and the later, more modern description by Bradshaw (2007: 45) attests a native 1, 2, $2+1$, $2+2$, ... system.

Viid (Border, Indonesia):

In one wordlist (a.2) of Viid from Senggi (Smits and Voorhoeve 1994: 211–212), 'tambla' is listed both with the meaning 2 and 3, but this is not borne out in other early wordlists (Smits and Voorhoeve 1994: 211–212) or the more recent (Menanti forthc.), which have $3 = 2+1$.

Gedaged (Oceanic/Austronesian, Papua New Guinea):

Nikolaj von Miklucho-Maclay, a pioneer researcher on the Rai-coast of Papua New Guinea, reports that (von der Gabelentz and Meyer 1882: 503):

> Sehr viele Papuas kennen die Zahlwörter ihres eigenen Dialektes nicht. In Mitebog [a village speaking a dialect of Gedaged – HH] fragte ich fünf oder sechs Eingeborene, aber die Angaben waren widersprechend und jedenfalls unrichtig, nur olam (eins) konnte ich als sicher notiren.
> [Very many Papuans do not know the numerals of their own dialect. In Mitebog I asked five or six natives, but the information given was contradictory and, in any case, erroneous, I could only note down olam (one) as certain.]

One interpretation of this statement is that there was no normed expression for numerals above 'one' in the lect of Mitebog. A later, longer description

of a different dialect shows monomorphemic numerals 1–5 inherited from Austronesian (Dempwolff n. d.: 36–37),

To lack numerals above one means that the normed expressions for the quantities above one are inexact. We may call such systems 1-few-many for the time being. In these languages, it may be possible to communicate a higher exact quantity successfully, perhaps using gestures, context, one-to-one pairings, repetition or a specialized lexical item e. g., 'twin' for a certain kind of exact quantity. However, in these languages, the normed expressions are still 'one', 'a few', 'many', ... when these quantities occur in discourse. In no case does it appear to be possible, or normed, to say $few + 1$, $1 + 1$ or $few + few$ to designate an $exact$ number, so there is no base.

From the above cases, one certainly gets the impression that there is a thin line between 1-few-many systems and 1-2-many systems. In some cases, different observers on the same language variety differ as to whether the 'two'-word is approximate or exact in meaning. In other cases, the speech community seems to have acquired norms for number expressions over time. One may then conjecture that many more 1-few-many systems would have been found if more languages had been documented in detail before extensive contact with modern society.[1] It is also apparent that questions on this level of granularity are almost beyond the scope of classical forms of language documentation. Of languages potentially showing 1-few-many systems or 1-2-many systems only two, Mundurukú (Mundurukú / Tupí, Brazil; Pica et al. 2004) and Pirahã (see below), have been subject to investigations approaching standards of experimental psychology.

There are two further languages in the Amazon, Pirahã (Mura-Pirahã, Brazil) and Xilixana (Yanomama, Brazil) that stand apart from the above 1-few-many systems in that they are argued to lack all exact numerals, i. e., there is no normed way to denote an exact quantity even for 'one'.

In Pirahã, there are two words which prototypically mean 'one' and 'a couple' respectively, but it has been checked fairly extensively that their meanings are fuzzy 'one' and 'two' rather than discrete quantities (Everett 2005, 2004; Frank et al. 2008). It is not possible to combine or repeat them to denote higher (inexact?) quantities either (Gordon 2004). The Pirahã have the same cognitive capabilities as other humans and they are able to perform tasks which require discerning exact numeration up to the subitizing limit, i. e., about 3 (Gordon 2004). They just do not have normed expressions even for low quantities, and live their life happily without paying much attention to exact numbers. It does not appear to be possible to express an exact quan-

tity simply by repeating an expression the appropriate number of times, like one can and often does in, e. g., Sanuma (Yanomama, Brazil) for 2 and 3 (Borgman 1990: 152). If one says "I'll be back after it gets dark and it gets dark again" this might just as well be interpreted as two days or as three days (p. c. Daniel L. Everett 2005). It seems relevant to note that Pirahã grammar lacks singular-plural distinctions of any kind, even in pronouns (p. c. Daniel L. Everett 2008). A wordlist of the only known relative of Pirahã, the extinct Mura language,[2] features words glossed 'one' and 'two' (Nimuendajú 1932; Nimuendajú and do Valle Bentes 1923). The 'one'-word is an obvious cognate to the Pirahã fuzzy one, and the 'two'-word is an obvious loan from some Tupi language.

Xilixana is the language of a group which has been on the Mucujai river at least for the past century. In modern divisions, it is sorted as a dialect of Ninam, also known as Yanam or Central Ninam (superseding Southern Ninam in older terminology) (Migliazza 1972). Swain (2000)[3] describes Xilixana numerals as not even having an exact 'one':

'one'	*mõli*	Note: Means 'one or a few'.
'two'	*kup*; *yalukup*	Note: Means 'two or a few'.
'three'	*pək*	Note: Can refer to any number more than two or a few.

John Peters, the first missionary to live among the same group, also describes the same expressions as having inexact value and adduces that "exact numbers were not important" (Peters 1998: 52). The closest other Yanomami variety for which there is a grammar is the dialect Shiriana, of the Uraricoera, to the north (Gómez 1990). This describes the numerals 'one' and 'two' as exact, but the author only spent 14 weeks in the field. Also Migliazza (1972: 117–118, 422), who spent many years in all of the Yanomama territory, describes Shiriana lower numerals as exact in the numerals section of his thesis and, in fact, all other description of Yanomama languages we have been able to consult describe 'one' and 'two' as exact (Ramirez 1994a, 1994b; Zerries and Schuster 1974; Becher 1960; Knobloch 1967; Vinci 1956; Wilbert 1962; de Matallana and de Armellada 1943; Koch-Grünberg 1928; Mattei-Müller 2007). Also, most Yanomama varieties have singular, dual and plural but we do not know the precise status of Xilixana, and if so, if they are inexact as well. However, on one page (Migliazza 1972: 38) the #moli word is glossed as 'one, few' (in contrast to pages 117–118 and 422). This is significant because language descriptions rarely claim 'one' and 'few' overlap in meaning,

and now three independent observers do it for the same or nearly the same language. Swain was a UFM / MEVA missionary who lived with the Xilixana for very long periods of time in the 1970–1990s and therefore she is certainly not a superficial observer. The Xilixana were monolingual (except for an occasional captured Dekwana) and uncontacted by modern society up to at least 1957 (Early and Peters 2000).

3.1.2 Base-3

Base-3 appears to be rarer than base-4. We have found only a few cases[4], some of them somewhat sporadic within their respective dialect cluster:

Ambulas of Wingei (Ndu, Papua New Guinea):

An Ambulas dialect survey (Wilson 1976: 57) mentions that the variety of Wingei counts in units of three, and the actual forms can be found in Wilson (1989a: 16–17). The forms are reproduced in Table 2 on the next page. Presumably, this is the same case that Laycock (1970) refers to when speaking (without forms given) of base-3-6-24 system(s) in the Ndu family, citing personal communication from Anthony Forge. The etymology of the forms reveal that the system is much like a commonplace 5-10-20 or 5-20 system except that the hand is seen as having six features! At the time of elicitation only older people knew the indigenous system, whereas the young used Tok Pisin or English for higher numerals. Other, better described, varieties of Ambulas (Wilson 1976, 1980) show no base-3 and comparative evidence shows that the original Ambulas (1-3) and Ndu (1-2) system were restricted (Aikhenvald 2008: 595; Laycock 1965: 173–174).

Waimirí of Atroarí (North Amazonian Carib / Cariban, Brazil):

Base-3 counting could be used up to about 9 according to Green (1997: 6–7), who cites personal communication with Ana Carla de Bruno Santos. However, the more recent grammar by Bruno (2003: 140–142) states that Portuguese loans are used above 3 and is silent about a possible base-3 alternative.

Som (Finisterre-Huon / Trans New Guinea, Papua New Guinea):

According to Smith (1988: 29) base-3 counting can be used up to about 9. We know of no other description of this variety.

Table 2. Numerals in Wingei Ambulas (Wilson 1989a: 16–17), Maprik Ambulas (Wilson 1980), Wosera-Mamu Ambulas from around Serangwandu (Wilson 1989b: 15) and Wosera-Kamu-K from around Kunjingini (Wilson 1990: 15).

	Wingei	Maprik	Wosera-Mamu	Wosera-Kamu-K
1	nawurak	nakurak	vétik	vétik
2	vétik	vétik	vétik	vétik
3	kupuk	kupuk	kupuk	kupuk
4	kupukiva	nakwasa/wan vétik wan vétik	vétik vétik	vétik vétik
5	kupuk'etik	naktaba	taambak	taambak
6	taabak	naktaba sékét naktaba nakurak		
7	taabak kaayek	naktaba sékét naktaba vétik		
8	taabak kaayek vétik	naktaba sékét naktaba kupuk		
9	taabak kaayek kupik	naktaba sékét naktaba kupuk wan vétik wan vétik		
10	vétik taaba vétik	taaba vétik		
11	nawurak taaba vétik	taaba vétik sékérék maan-ba kayék nakurak		
12	taaba vétik	taaba vétik sékérék maan-ba kayék vétik		
20		maan vétik taava vétik	nakurak mi	nakurak dumi / maan vétik taaba vétik
24	nawura mi			

Etymologies of roots are as follows #maa is 'foot, leg', #taaba is 'hand, arm', #mi is 'tree' and #du is 'man'. Apparently, in Wingei counting, the hand is seen to have six features. The etymology of the expresssion *nawura mi / nakurak mi / nakurak dumi* is not clear but it may have to do with either tree (typologically unusual but matches *mi*) or man (typologically very common, but resembles only *dumi*).

Bine (Eastern Trans-Fly, Papua New Guinea):

In at least one vocabulary repoduced in Wolfers (1972: 218) and Wolfers (1971: 79), a variety of Bine is base-3 and reaches up to 9. However, all other attestations of Bine show only a restricted system and / or a body-tally system (Lean 1986d), including the lengthiest description (Fleischmann and Turpeinen 1975: 16). The base-3 vocabulary must therefore be considered somewhat dubious.

Bukiyip (Arapeshan[5], Papua New Guinea):

Fortune (1942: 58–60) describes the Rohwim dialect of Mountain Arapesh to have a base-3 system for counting some objects and a base-4 system for counting other objects, which seems to have reached up to 24. A later description of an inland Bukiyip (Conrad and Wogiga 1991: 73–76) variety shows a conflation of the two systems (with no indication of them being used for different objects). Conrad submitted the base-3 system for the entry on Bukiyip (dialect not indicated) on the *Numeral Systems of the World's Languages* website.[6] Available data on other Arapeshan languages, such as Abu' Arapesh (Nekitel 1985: 82–84) and Mufian (Conrad et al. 1978: 104), show base-5, at least from 7 and up.

3.1.3 Base-4

Base-4 systems are attested on four continents:

North America:

Some extinct Chumash languages (Chumashan, USA) show original base-4 systems, running up to 32 (Beeler 1967, 1963; Hughes 1974; Mamet 2005: 113–115). Base-4-8 is also documented with the older generation in the now extinct Yuki (Isolate, USA). For Yuki, Kroeber (1925) describes how base-4 is related to hand-counting by considering the spaces between the fingers (cf. Hinton 1994[7]). The Chumashan languages and Yuki are both in California but quite distantly apart, with Yuki in the north and Chumashan in the south, and other language families intervening.

South America:

The extinct Lule (Isolate, Argentina) of Clark (1937: 102) and Machoni de Cerdeña (1732: 84–86) as well as the poorly attested extinct Charrúa

(Charruan, Uruguay) reported in Ibarra Grasso (1939b: 202) appear to have had base-4 up to 10, at which point the system turns into a commonplace 5-10-20 system with hands and feet. It cannot be inferred from the data at hand that there was ever a true base-4 system here, beyond 10.

A couple of descriptions of a Guaraní variety in Paraguay (Tupí-Guaraní / Tupi, Paraguay) show base-4 up to 10, but the expressions for numbers above 10 are not shown (Ibarra Grasso 1938: 278, 1939a: 590). Other old and new descriptions of any varieties of Guaraní (too many to list) do not show any traces of base-4. Isolated vocabularies of Mocovi and Toba (Guaicuruan, Argentina) show base-4 up to 8 and 10 respectively (Koch-Grünberg 1903: 114–124), but the vast majority of vocabularies for these languages (too many to list) show no trace of this.

The extinct Payaguá (Isolate[8], Paraguay) has one attestation with alternative base-4 forms up to 20 (Koch-Grünberg 1903: 114–124). All these cases occur within a relatively small area of South America, but there is otherwise little evidence for an areal connection.

Oceania:

An indeterminate number of languages in the New Guinea highlands have a variations of a base-4 system (Lean 1986a: 13–86, 1986c: 15–59, 1992: Ch. 5), where at least one, Kakoli (Hagen / Trans New Guinea, Papua New Guinea) is attested with base 4-24 (Bowers and Lepi 1975). Kewa (Engan / Trans New Guinea, Papua New Guinea) has several parallel numeral systems, one of them being base-4 (Franklin and Franklin 1962) and goes at least up to 20, and beyond that it may be combined with a body-tally system to form higher numbers in units of four (Pumuge 1975). The word for '4' is 'hand', i. e., four fingers constitute one hand and the thumb is separate. The traditional counting system of Mbowamb (Hagen / Trans New Guinea, Papua New Guinea) near Mt. Hagen has been been described with a fair amount of detail. It is clearly a 2-4-8 system, for which Vicedom and Tischner (1948: 268–270) give expressions up to 24, and say the system can be used up to about 80. Another description seems to indicate that after 20, counting can be done in units of 20 (Strauss 1962: 315–318), cf. also Lancy and Strathern (1981). As in Kewa, the base-4 is connected with counting the fingers of one hand, the thumb counted separately. The origin of the highland base-4 system(s) has not been systematically investigated, but given the geographical proximity and the fact that the Engan and Hagen languages are not closely related,

an areal connection seems likely even if this is not directly observable in the forms in question.

On the north coast, around the border between Indonesian Papua and Papua New Guinea, base-4 is also present variously in the Sko languages (most of the data is collected in in Lean (1986b), but see Donohue (2008) for a good attestation of 4-12-24 in Skou) as well as 4-24 in Tobati (Sarmi-Jayapura Bay / Austronesian) for which the best attestation is Moolenburgh (1904). Given the proximity of the languages and the fact that they are genetically unrelated, there is almost certainly an areal connection between base-4 in Skou and the Sarmi-Jayapura Bay Oceanic languages.

Africa:

An indeterminate number of languages in the northeastern Democratic Republic of the Congo (DRC) have (traces of) a base-4 system. The first attestation appears to be a Nyali (Bantu, DRC) variety for which Stuhlmann (1894: 624) notes that $8 = 2 * 4$, $9 = 2 * 4 + 1$, $13 = 12 + 1$, $14 = 12 + 2$, $16 = 2 * 8$, $17 = 2 * 8 + 1$ but $20 = 2 * 10$. Later reports of related Bantu varieties show that there was / is a fully systematic 4-24 or 4-32 underlying these forms (van Geluwe 1960; Kalunga Mwela-Ubi 1999; Bokula and Ngandi 1985). Furthermore, thanks to Kutsch Lojenga (1994a: 353–357), we have a full attestation of almost obsolete Ngiti (Lendu / Central Sudanic, DRC) and Lendu (Lendu / Central Sudanic, DRC) 4-32 systems (p. c. Constance Kutsch Lojenga 2007). Various wordlists attest traces of the same base-4 systems in decay or amalgamation with base-10 and base-20 in closely related Bantu and Central Sudanic languages (Johnston 1922b; Struck 1910; Johnston 1904; Bokula 1970; Harries 1959; Kutsch Lojenga 1994b; Schebesta 1966, 1934; Asangama 1983; Czekanowski 1924; Stuhlmann 1917; and unpublished SIL survey lists).

Non-cases

In addition, there are a number of languages which have been claimed to be base-4 in the literature but which are not base-4 according to the definition used in this paper. We will mention a few of the most important ones here. The language called Āfúdu (Unassigned[9], West Africa) by Koelle (1854) uses some additions with 4 in the numbers below 10 but is decimal in the range 10–20. Bodo and Deuri (Bodo-Garo / Sino-Tibetan, India) have vestiges of base-4 counting extending higher than 20 and Bai (Bai / Sino-Tibetan, China) is documented with a base-4-16-80 system for shell money in medieval times

(Mazaudon 2007). Yiwom (West Chadic A / Afro-Asiatic, Nigeria) has 7–9 as 4 + 3, 4 + 4, 4 + 5 but no other forms are based on 4 (Ibriszimow 1988). De Castelnau (1851a: 10–13) reports base-4 (actually base-2-4) in Apinayé (Jê / Jê-Jabutí, Brazil) but no actual forms are given (de Castelnau 1851b: 270–274) and is likely to be spurious in the absence of corroborating data in this rather well-documented language (too many references to list). Base-4 for counting special objects is widely attested in the Oceanic languages of Melanesia (Kolia 1975; Friederici 1912; Parkinson 1907).

3.1.4 Base-6

Base-6 systems are attested on Kolopom Island (formerly Frederik-Hendrik-Eiland) in southwest Indonesian Papua, as well as in the Kanum and Nambu languages in southern New Guinea around the Indonesian-Papua New Guinea border. Their origins have been discussed extensively (Donohue 2008; Evans 2009; Hammarström 2009; Plank 2009) and need not be repeated here.

In addition, there are a number of languages which have been claimed to be base-6 in the literature but which are not base-6 according to the definition used in this paper (cf. Plank 2009; Gamble 1980; Beeler 1961; Ibarra Grasso 1939b). A few require comment. One early attestation of Balanta (Northern Atlantic / Atlantic-Congo, Senegal / Guinea Bissau) has additions of 6 for the numbers 7–12 (Koelle 1854). But since we do not know the continuation beyond 12, it is unsure whether the 6:s generalize (cf. Wilson 1961a). Also, later attestations give different, non-base-6, forms (Wilson 1961b; Quintina 1961; Fudeman 1999). Similarly, Less Traditional Tiwi (Isolate, Australia) may have formed some numbers in the range 7–10 with 6 (Lee 1987: 96–100), but not further.

3.1.5 Base-8

Northern Pame (Otopamean / Otomanguean, Mexico), the sole case of a base-8 language (attested up to 32) which does not have 4 as a sub-base is presented and discussed in Avelino (2006), though 5–8 have etymologies which involve 5.

3.1.6 Base-12

Dhivehi (Indo-Aryan / Indo-European, Maldives) has an early attested (Gray 1878) but long extinct base-12 which is attested up to 96 thanks to the ef-

forts of Fritz (2002: 107–123).[10] Apart from that case, there are base-12 systems in the Plateau area of northern Nigeria. The first known attestations of such systems[11] come from the famous *Polyglotta Africana* by Koelle (1854) which includes numerals 1–20 in a number of West African languages and the first proclamation of duodecimality as a system appears to be Schubert's (1888). As shown in Table 3, we have tried to collect all independent attestations that have been published, or, are unpublished but available on the internet.[12] However, not all of them are necessarily independent as this information is not always deducible from the text. It is likely that there are a few more attestations in publications that we do not have access to. For many, if not all, other sources on the same varieties attest base-10 rather than base-12, which means that the base-12 systems are currently under pressure.

Table 3 shows published attestation of base-12 systems in the Plateau area. $12-144$ means that the attestation gives forms ≤ 12, forms $12+x$, multiples of 12, and a word for 144; 12+ means forms ≤ 12 and forms $12+x$ or multiples of 12; ≤ 12 means forms ≤ 12; "12" means that the source simply states that there was a "duodecimal system" but gives no forms; Cont.-10 means an attested 10-system contaminated by forms following a "duodecimal system" and Spec.-12 means that some duodecimal connection is speculated. Further half-attestations are as follows. Arago (base-10 in Judd 1923), Kagoma and Agatu were judged "uncertain" by Thomas (1920a). Gwara, a Margi variety (Biu-Mandara A / Afro-Asiatic, Nigeria) has monomorphemic 1–10 and forms 11–12 with formations that may include 1 and 2 – a bit like Germanic – but there is otherwise no reason to suspect base-12 counting (Wolff 1975).

Table 3. Published attestation of base-12 systems in the Plateau area.

Language	Source	Type	Family	Comment
Ake	Blench 2006a	≤ 12	Plateau	
Afo	Bouquiaux 1962	"12"	Plateau	
Afo (Apho)	Bouquiaux 1962	"12"	Plateau	
Afo (extinct Afu)	Thomas 1920a	"12"	Plateau	
Afo	Meek 1925: 142–143	12+	Plateau	
Afo (Eloyi)	Mackay 1964; Armstrong 1983	12+	Plateau	
Aten	Blench 2006d	≤ 12	Plateau	
Aten (Ganawuri)	Bouquiaux 1964, 1962	12–144	Plateau	
Aten (Ganawuri)	Meek 1925: 142–143	12+	Plateau	

Continued on next page

Language	Source	Type	Family	Comment
Birom	Bouquiaux 1970	12–144	Plateau	
Birom	Thomas 1920b	"12"	Plateau	
Birom (Tahoss)	Blench 2006g	≤ 12	Plateau	
Che (Rukuba)	Gerhardt 1987	Spec.-12	Plateau	Cites BCCWL.
Che (Rukuba)	Blench et al. 2006	≤ 12	Plateau	
Eggon	Blench and Hepburn 2006	≤ 12	Plateau	
Eggon	Gerhardt 1983: 47	"12"	Plateau	
Eggon	Gerhardt 1987	"12"	Plateau	Cites Gospel 1935 + Lukas 1952 field-notes
Eggon	Shimizu 1975	"12"	Plateau	
Hyam	de Castelnau 1851c: 59	≤ 12	Plateau	
Hyam (Jaba-Kwoi)	Meek 1931: 123	12–144	Plateau	Also base-10 forms
Hyam (Jaba)	Bouquiaux 1962	"12"	Plateau	
Hyam	Thomas 1920b	≤ 12	Plateau	
Hyam	Blench 2006f	≤ 12	Plateau	
Ikulu	Seitz 1993: 37–38	Spec.-12	Plateau	
Izere (Fobur)	Blench and Kaze 2006	≤ 12	Plateau	
Izere (Ganang)	Blench 2006c	≤ 12	Plateau	
Izere (Zarek-Gana)	Gerhardt 1987	"12"	Plateau	Citing BCCWL
Kaningkom	Gerhardt 1987	"12"	Plateau	
Koro	Thomas 1920b	12+	Plateau	
Koro	Williamson 1973: 453	12+	Plateau	
Koro (Idū)	Blench 2009a	12+	Plateau	
Koro (Nyankpa)	Thomas 1920b; Gerhardt 2005; Blench 2009b	12+	Plateau	
Koro (Tinɔr)	Gerhardt 1973	"12"	Plateau	
Koro (Tinɔr)	Blench 2009c	≤ 12	Plateau	
Lungu	Gerhardt 1987	"12"	Plateau	
Mada	Blench and Kato 2006	≤ 12	Plateau	
Mada	Thomas 1920a	"12"	Plateau	
Mada (S. Mada)	Mathews 1917	12–144	Plateau	
Ninkyop	Blench 2006e	≤ 12	Plateau	
Ninzam	Mathews 1917	12–144	Plateau	
Ninzam	Thomas 1920a	"12"	Plateau	
Nungu	Mathews 1917	12–144	Plateau	
Nungu	Thomas 1920a	"12"	Plateau	
Rigwe	Bouquiaux 1962	"12"	Plateau	
Rigwe	Gerhardt 1987	"12"	Plateau	
Rigwe	Gerhardt 1969: 125–127	≤ 12	Plateau	

Continued on next page

Language	Source	Type	Family	Comment
Teria (Cara)	Blench 2006b	≤ 12	Plateau	
Teria / Fachara	Meek 1925: 142–143	12+	Plateau	
Tesu	Blench 2006f, 2006h	≤ 12	Plateau	
Tyap (Gworok)	Adwiraah 1989	"12"	Plateau	
Tyap (Gworok)	Gerhardt 1987	≤ 12	Plateau	Not confirmed in Gerhardt 1968
Amo	Luzio 1973	Cont.-10	E. Kainji	
Gure	Meek 1931: 203	≤ 12	E. Kainji	
Iguta	Shimizu 1979	12+	E. Kainji	
Janji	Meek 1931: 185–187	≤ 12	E. Kainji	
Janji	Shimizu 1979	≤ 12	E. Kainji	
Janji	Bouquiaux 1962	"12"	E. Kainji	
Jere	Shimizu 1982	≤ 12	E. Kainji	Not Sheni, Ziriya, Gana, Taura, Shau, Gyem, Gamo
Jere (Boze, Akwẹrẹ clan)	Nengel n. d., 1999	≤ 12	E. Kainji	
Kahugu	Meek 1931: 212	≤ 12	E. Kainji	
Lemoro	Shimizu 1979	≤ 12	E. Kainji	Not Cokobo
Piti	Meek 1931: 139	12+	E. Kainji	Switched to base-10
Piti	Matsushita 1998	"12"	E. Kainji	
Rop	Meek 1925: 142–143	12+	E. Kainji	
Sanga	Shimizu 1979	≤ 12	E. Kainji	
Dyarim	Blench 2007	Spec.-12	W. Chadic	Etymological Connection
Gwandara	Shimizu 1975	"12"	W. Chadic	Citing P. Newman p. c.
Gwandara (Nimbia)	Matsushita 1998	12–144	W. Chadic	
Mwaghvul	Jungraithmayr 1963	12+	W. Chadic	
Ron of Daffo	Seibert 1998	12+	W. Chadic	Not confirmed in Jungraithmayr 1970
Mumuye	Matsushita 1998	"12"	Adamawa	Not Zing Mumuye pace Shimizu 1983
Mama (Kantana)	Gerhardt 1987	"12"	Jarawan Bantu	
Mama	Thomas 1927	≤ 12	Jarawan Bantu	
Mama	Mathews 1917	12–144	Jarawan Bantu	
Mama	Thomas 1920a	"12"	Jarawan Bantu	

The base-12 systems occur only in languages in the area of Jos plateau of Nigeria, but which belong to different (sub-)families, namely Plateau (Atlantic-Congo), East Kainji (Atlantic-Congo), West Chadic (Afro-Asiatic), Adamawa (Atlantic-Congo) and Jarawan Bantu (Atlantic-Congo). A root resembling *#sok* for 12, with plausible sound correspondences (Gerhardt reconstructs **suak*), is widespread in Plateau, wherefore it is very likely that base-12 is old in Plateau. The same root occurs in Jarawan Bantu and Ron of Daffo, both of which are isolated instances of this root, or indeed base-12, in their respective families, so borrowing from (proto-southwest) Plateau is highly likely if not certain, as concluded by Maddieson and Williamson (1975: 136) and Gerhardt (1997: 140–141) for Jarawan Bantu. In East Kainji and the Beromic subgroup of Plateau, a root *#kuri* occurs for 12, which makes a borrowing in either direction likely. Furthermore, *#piri* is 12 in Gure and Kahugu (East Kainji) and *#zowa* is 12 in Ake and Koro (Plateau) and yet other roots for 12 appear in the remaining West Chadic cases. Since base-12 is so rare in the languages of the world, the variety of non-ancient roots suggest that a base-12 *system* may be borrowed even without key morphemes. The root for 12 in the alleged Mumuye variety with base-12 is not known.

There are no obvious clues as to the unusual choice of 12 as a base. A few of the base-12 languages in Meek (1931) have hand gestures that often are used accompanying the spoken expression. A combination of fingers and eyes make up 12 in at least one of these cases, but no traces of words meaning ‘eye’, ‘hand’ or ‘finger’ can be found in the corresponding spoken expressions. On the other hand, although not a base, 12 bears a special position in several modern European languages too, with a special word like ‘dozen’ and an elevated frequency (Dehaene and Mehler 1992). The reason(s) for this is not well-understood either.

3.1.7 Base-15

There appears to be only one case of a language attested as base-15, at least for a number of decades, namely Huli (East New Guinea Highlands / Trans New Guinea, Papua New Guinea) of the southern highland fringes. It is clearly an original body-tally system with a cycle of 29 – midway / center-point is thus 15 – which under influence from a Tok Pisin base-system turned into base-15 (Cheetham 1978; Lomas 1988).

3.1.8 Rare second bases

Some rarities in the next higher bases after 5, 10 or 20 are as follows:

10–40:

Pech (Paya / Chibchan, Honduras) as of Conzemius (1928: 264–265) and Hawaiian (Oceanic / Austronesian, USA) until it restructured to 10–100 under foreign pressure (von Chamisso 1837; Dwight 1848; Hughes 1982).

5-20-40:

Southwestern Pomo (Pomoan, USA) in one attestation (Closs 1986: 35–41).

10-60:

Attested (Drabbe 1952) in Ekagi (Paniai Lakes / Trans New Guinea, Indonesia) and Ntomba (Bantu / Atlantic-Congo, DRC) until it restructured to 10–100 under foreign pressure (Gilliard 1928, 1924).

5-10-20-60:

Famously known from the long extinct Sumerian (Isolate, Iraq), see, e. g. Powell (1972).

(5-)10-20-(60 /)80:

Attested in Mande (Monteil 1905; Dombrowski and Dombrowski 1991; Delafosse 1928; Hartner 1943), Dogon (Calame-Griaule 1968), Gur (Carlson 1994; Welmers 1950: 167–169) and Bangi Me (Blench 2005) languages in a relatively small area in West Africa, wherefore an areal connection is almost certain. In the Mande attestations, the systems vary between 60 and 80 as per a certain root that sometimes means 60 and sometimes 80.

5-25:

Gumatj (Yolngu / Pama-Nyungan, Australia) is described, with ample examples, to be 5-25 (up to 625). However, one would not usually use exact numbers for counting this high in this language and there is a certain likelihood that the system was extended this high only at the time of elicitation with one single speaker (Harris 1982; Sobek p. c.).

At least one speaker of Biwat (Yuat River, Papua New Guinea) appears to have made the same 5-25 innovation (McElvenny 2006), as two other earlier

attestations rather show a commonplace 5-20 system (Haberland and Seyfarth 1974; Mead 1932).[13]

It is remarkable that there is no incontestable attestation of a 5-25 system that extends to a whole speech community.[14] The contrast with 5-20 systems, which are ubiquitous, reveals much as to the evolution of normed number expression within a community.

3.1.9 Last notes

At least two cases of alleged base-11 exist, both of which appear to be mistaken. Pañgwa (Bantu / Atlantic-Congo, Tanzania) is presented with a base-11 vocabulary (Johnston 1922a: 477), but this cannot be corroborated in other attestations (Stirnimann 1983) so it is presumably an error.

A fairly early discussion of Māori (Balbi 1826: 256–257) likewise claims undecimality, but this was refuted already in the same century (Conant 1896: 122–123). One alleged case of counting in 30s is in Klingenheben (1927: 43) but this too has failed to be corroborated later.

3.2 Other rarities

Other than rare bases, there are a few very interesting rarities which we mention below.

3.2.1 Streak of unanalyzable forms

Several, but not all, of the base-12 languages have monomorphemic words for all of 1–12 as does, e. g., Chalchihuitán Tzotzil (Mayan, Mexico) (Hopkins 1967: 16). However, the record streak appears to be 15, as evidenced in Chocho of Santa Catarina Ocotlán (Popolocan / Oto-Manguean, Mexico) in Table 4 on the next page.[15]

A claim of monomorphemic 1–20 in Munda (subfamily of Austroasiatic, India) appears, on closer scrutiny, to be artificial or unsubstantiated.[16]

3.2.2 Order of additive units

As we have seen, all languages which have numerals above 20 form the higher numbers using addition and multiplication of integers (and occasion-

Table 4. The monomorphemic numerals up to 15 in Chocho of Santa Catarina Ocotlán. 15–19 are formed as 15+1 etc and 20 is a base (Veerman-Leichsenring 2000: 33–34), cf. also Mock (1977: 153–154).

1 ngū	6 šū̱	11 tǫ́
2 žú	7 žàadù	12 rxá
3 nīé	8 šį́	13 šé
4 ňū̱ǫ́	9 nīà	14 rxǫ̀
5 žǫ́	10 tè	15 rxǫ̀ʔ

ally subtraction as well multiplication with fractions). Both addition and subtraction are commutative operations so languages are free to change the order of the operands. Not surprisingly, the order of multiplier and multiplicand is usually the same as the order of numeral and noun in the language in question. For additive units the situation is more interesting. For expressions where the sum is less than, say, a 100, we find both smaller-precedes-larger and larger-precedes-smaller in the languages of the world. A lot of languages have one order for the teens and the opposite order for higher sums. For sums above 100, the situation is quite different. Almost all languages, and a multitude of the cases must be independent, show larger-precedes-smaller order. At least three ancient languages[17] – Classical Attic Greek, Classical Arabic, Sanskrit (as well as Vedic) – are attested with both orders possible. The only modern languages with invariable smaller-bigger order between additive units in numeral expressions ≥ 100 appear to be (certain dialects of) Malagasy (Barito / Austronesian, Madagascar), Chuj (Mayan, Guatemala) and Tzotzil (Mayan, Mexico),[18] see Daval-Markussen et al. (in press) for references.

3.2.3 Cardinal dominance?

In natural languages, it appears that cardinal numerals hold a primary position over other kinds of numerals, e. g., distributive numerals, and exact number marking in general, in the sense that the non-cardinals are morphosyntactically derived from the cardinals and that the cardinals run higher. The dominance appears to be exceptionless for all languages which have numerals above 3, but we will review two interesting challenges below.

One description of a Great Andamanese variety explicitly says that there are more ordinals than cardinals (Man 1883a: 100), or – to be more specific – that there are only two cardinals but six ordinals. But a closer inspection of

the forms reveals that the six "ordinals" are not true ordinals. 3–6 do not mean 'third'–'sixth' but 'in the middle', 'the next one', 'last' and so on. They only acquire the fixed ordinal meaning in the context of a game or the like when the number of participants is known (Man 1883b: 413).

One description (Mathews 1904) of Wuddyāwūrru (West Victoria / Pama-Nyungan, Australia) says that there are more grammatical numbers (singular, plural, *trial*, and plural) than cardinals (one, two). This is not contradicted by other sources on the same or related languages (too many to list). However, there is no linguistic data in this case to ascertain that the trial was a true trial (rather than a paucal) and Mathews has described many other Australian languages as having trials where this is questionable (p. c. Barry Blake 2005). We will never know for sure whether this language had a true trial or not, since the language is extinct.

4 Conclusion

This paper has surveyed rarities for a number of structural properties of numeral systems. We have given full primacy to data presentation rather than interpretation to make the factual status of the data maximally clear. With this, we hope to have set the stage for future generalizations and interpretations of rareness with a high level of empirical validity.

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Notes

1. Further cases may include the following. **1.** Aikhenvald and Dixon (1999: 358) conjecture that Djeoromitxí (Jabutí / Jê-Jabutí, Brazil) "originally had no numbers" since the word *je-bo* for 'two' given by Pires (1992: 66) is from a root with the meaning to 'be equal'. However, an etymology for 'two', even if correct (cf. van der Voort 2004: 212; 2007: 162) does not automatically mean that there was no original word for 'two', nor that a present meaning of 'two' (Ribeiro 2008: 42) is somehow subordinate to the etymological meaning. Also, an early attestation of *yawo yawo* (2 + 2) for 4 in (Loukotka 1963: 50) speaks against an inexact meaning for 'two'. **2.** Barriga Puente (1998: 132, 263) reports that Esmeraldeño (Isolate, Ecuador) has a limit of counting at one, based on a misreading of Lehmann (1920: 37). There is only one vocabulary of the now extinct Esmeraldeño which has been reprinted a number of times (Adelaar 2004: 155–161). However, the earliest of these publications (Wolf 1892: 528) is clear that the lack of native Esmeraldeño words above one could be due to the memory of the last speaker(s). So we are not in a position to assert that Esmeraldeẽno ever lacked numerals above one. **3.** Koch-Grünberg (1928: 316) describes numerals in Sapé (Isolate, Venezuela) as 1 'mẹ̯yakán' and 2 'mẹ̯yakán' and remarks

> "Die Kaliána haben nur ein Zahlwort und gebrauchen stets denselben Ausdruck, in dem sie dabei an den Fingern und dann an den Zehen weiterzählen".
>
> [The Kaliána have but one numeral and always use the same expression while they continue to count using their fingers and toes.]

It's not clear what to make of this, but, in any case, the only other two published vocabularies do show distinct words for lower numerals (de Matallana and de Armellada 1943; Migliazza 1978) and Koch-Grünberg's vocabularies contain other cases of puzzling numeral elicitations (Zerries and Schuster 1974: 56). **4.** It is hard to know whether the Guayakí variety recorded from two youths by Vogt extended to a whole community of speakers (Vogt 1903: 861) and another attestation from roughly the same time appears to give forms for exact 1 and 2 (Mayntzhusen 1920: 20), though it may be that these forms are etymologizable (Vellard 1935). **5.** On the grounds that the present-day numerals can be etymologized to 'that', 'pair / couple', 'few' and 'another', Proto-Tupi

(Schleicher 1998: 12–13) may be argued to lack numerals. **6.** A vocabulary of Ofaye has 1 hœhá, 2 ñokoádi, 3 ñokoádn 4 ñokoádi (Hanke 1964: 29), i. e., 2 is the same as 4. A good guess, following more recent documentation (das Dores de Oliveira 2006: 109–110), is that the 4 in this earlier vocabulary is simply an error of some kind. **7.** Bernatzik (1942) claims that Yumbri lacked numerals above one. There is no further material on this variety but the closely related Minor Mlabri (Rischel 1995) has numerals up to three. Bernatzik's account has a sweeping and condescending flavour, and also has other doubtful claims of the same kind, e. g., lack of fiction which does not hold for Minor Mlabri either (cf. Velder 1963: 15). Another complicating factor is that he is able to discuss twin births at length with the people he says cannot comprehend any more distinctions than 'one' and 'many'. **8.** The oft-repeated claim (Parker 1909: 85) of lack of numerals in Vedda (Unclassified, Sri Lanka) appears, on closer scrutiny of the underlying sources, to be hearsay (Seligmann and Seligmann 1911: 33, 412). The only thing we can say is that no native term above two could be collected from the memories of the descendants, which does not necessarily mean that none existed. **9.** The first record of the language of Utanata (Asmat-Kamoro / Trans New Guinea, Indonesia) indicates counting inability on the part of the inhabitants (Earl 1837). However, lower numerals are attested in all subsequent descriptions – especially the most extensive piece (Drabbe 1953) – and have cognates in other Asmat-Kamoro languages (Galis 1955). Therefore, the counting inability reported probably reflects some kind of misunderstanding in the midst of the very difficult communication circumstances. **10.** Grondona (1998: 91) conjectures that pre-contact Mocoví (Guaicuruan, Argentina) lacked numerals above one as 2 and above are Spanish loans ("It seems that Mocoví lacked numeral forms, and has borrowed all its numerals from Spanish"). While it is true that Mocoví borrowed 2 and above from Spanish (cf. Gualdieri (1998: 211–212) and for the related Pilagá (Vidal 2001: 129)), it does not necessarily follow that Mocoví lacked 2 and above, before the borrowing. Older sources do, in fact, consistently attest a specific form for 2, see Koch-Grünberg (1903: 112–124) as well as Lafone Quevedo (1893: 244 and 1892: 410) **11.** Paiconeca (Bolivia-Parana / Arawakan, Bolivia) is a poorly attested extinct language of presumed Arawakan affiliation (Montaño Aragón 1989: 161–173). The naturalist d'Orbigny (1839: 191) travelled through the area in the 19th century and is the only source for numerals in the language. Since this is the only source, we can neither confirm or deny his report of lack of numerals:

> Il n'y a, dans cette langue, aucun système de numération, qu'y remplacent à peine quelques termes de comparaison, eux-mêmes, très-bornés.
>
> [In this language, there is no numeral system, in the place of which they are only just able to substitute some terms for comparison, which are themselves very narrow-minded.]

12. In all descriptive publications, Khoedam (Khoe / Khoe-Kwadi, Namibia) *|úí* and *|áḿ* are glossed as 'one' and 'two' respectively, but closer inspection reveals that these are really meanings accustomed to linguistic elicitation, and 'singleness' and 'dualness' are more appropriate glossings. There is a subtle difference between 'dualness' and 'twoness' in that dualness implies an association between the items in question. So "*|áḿ* children" would mean 'twins' rather than 'two children'. If this difference is deemed significant, then there was no word for 'two' in traditional Khoedam (Brenzinger 2009).

2. We regret that we have not been able to access two relevant-looking publications on the Mura language (Hanke 1950, 1952).

3. Swain has also submitted the same information for the Ninam entry for the *Numeral Systems of the World's Languages* website at http://lingweb.eva.mpg.de/numeral/Ninam.htm, accessed 1 July 2009.
4. Ross and Paul (1978: 60) give expressions for 1–8 in Waskia (Adelbert Range / Trans New Guinea, Papua New Guinea) with the structure 1, 2, $2+1$, $2+2$, $2+2+1$, $(2+1)+(2+1)$, $(2+1)+(2+1)+1$, $(2+1)+(2+1)+2$, that is, 6–8 are formed with additions based on $(2+1)+(2+1)$ for 6. This comes close, but does not count as base-3 according to the definition used in this paper.
5. Due to lack of data, we cannot confirm that the Arapeshan langages are related to Kombio or other groups usually subsumed under Torricelli.
6. Shown at http://lingweb.eva.mpg.de/numeral/Bukiyip.htm, accessed 1 July 2009.
7. We wish to thank Peter Bakker for highlighting this reference to us.
8. Payaguá, though poorly attested, is often counted as related to (at least) the Guaicuruan languages (Viegas Barros 2004) but we do not think the evidence is conclusive.
9. This language has not yet been identified with any modern variety (p. c. Jouni Filip Maho 2004; p. c. Roger Blench 2009).
10. With some speculative etymologizing, Chepang (Mahakiranti / Sino-Tibetan, Nepal) may have had 12 atoms and duodecimal counting up to 50, for a counting system associated with hunting (Caughley 1988, 1972; Hale 1973). One synopsis of Brúnkajk (Talamancan / Chibchan, Costa Rica) says that "también se cuenta por medio de docenas" (Arroyo Soto 1972: 32), but it is not clear on what this statement is based. It is not corroborated by a ten or so other descriptions of Brúnkajk, and it was not normed anyway, so it does not count as a base-12 system. In a modern description of Kinikinau (Bolivia-Parana / Arawakan, Brazil) higher numbers may be expressed using (dúzias) dozens (de Carvalho Couto 2005: 51), but this does not appear to be normed for exact enumeration of quantities that are not exact multiplies of twelve.
11. However, vocabularies including monomorphemic 1–12 are listed for Hyam (there called 'Java') a few years earlier (de Castelnau 1851c: 59).
12. We wish to thank Roger Blench for help with sorting out various Plateau language identifications and classification questions.
13. We wish to thank James McElvenny for access to archival material on Biwat.
14. The extinct Saraveka has 'five hands' attested for 25 but no numerals 20–24 nor above 25 are recorded (de Créqui-Montfort and Rivet 1913). The 5-25-50 counting system in Kikongo (Bantu / Atlantic-Congo, DRC) referred to in Schmidl (1915: 181) was for counting pearls only (Laman 1968, 1912, 1936).
15. We wish to thank Thomas Hanke for bringing this case to our attention.
16. Sharma (2003: 63) claims that

    > We may say Munda speakers are the earliest known people who practised this system of counting which had monomorphemic units of counting up to twenty.

    but gives no source and no forms. Monomorphemic 1–20 forms cannot be found in the monograph on Munda numerals by Zide (1978) nor in any published description of Kharia or any other Munda language we have been able to consult. Nevertheless, a recent unpublished description of Kharia (Peterson 2006: 138–139), a set of monomorphemic 11–19 are recorded as alternative forms alongside a set of composite forms. Peterson notes, however, that the monomorphemic forms were given to him by youths who all confirmed that they had be taught them in school (and themselves used Sadani loans for

the numbers in question). Further inquiries by Peterson with experienced local teachers also point towards an "artificial" origin of the 11–19 forms (p. c. John Peterson 2008).

17. A modern example may be the recently innovated Palikúr (North Arawak / Arawak, Brazil-Guyana) numeral system, but it is not fully clear what the norms are Green (1994); Launey (2003).
18. We wish to thank Aymeric Daval Rasmussen for bringing the Mayan cases to our attention.

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Additional rarities in the typology of numerals

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1 Introduction

This article deals with semantic and formal properties of numeral addition. Among the various types of quantifiers, there exists

> "the particularly privileged category [...] of *cardinal numerals* – quantifiers which refer to natural numbers, for example *one*, *two*, *thirteen*, *one hundred and twenty seven* [...]." (Gil 2001: 1278; emphasis in the original).

Numeral systems can be restricted to a few values, e. g. 1 to 3 or 4, or be practically unlimited: in languages like English, if the available numerals do not suffice to express a value, a new term is easily available, as seen in the growing use of *billion* and *trillion* in financial and other contexts.

Typological and other linguistic investigations of numerals have dealt with a wide range of topics, as evidenced by Greenberg (1978), Hurford (1975, 1987), Comrie (1997, 1999), and Gil (2001). A basic dichotomy distinguishes the external behavior of numerals and their internal make-up, i. e. the composition of numerals out of other numeral expressions. There exist some languages that lack complex numerals at all. Leaving that aside, higher numeral values are expressed by combining items of lower values.

The most widespread semantic relation between parts of numerals is addition, closely followed by multiplication. — Subtraction and division, which both employ higher values, are rarely employed. In fact, sums are in some languages the only semantic relation employed to construct complex numerals out of components.

Only recently, studies on numerals have employed worldwide samples that are explicitly described. As part of *The World Atlas of Language Structures*, Comrie (2005) offers a worldwide overview of "one aspect of the mathematical structure of linguistic expressions of numerals, namely the arithmetic base that is used in constructing numeral expressions" (2005: 530). In cases of doubt, "[...] preference has been given to the base that is most productive in the range 20–400" (Comrie 2005: 531).