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Beyond endangered:

Some reflections on the future of indigenous numeral systems

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Abstract

Papua New Guinea, and the New Guinea area more generally, is home to a rich array of indigenous numeral systems, including some that are typologically unusual. As in much of the rest of the world, indigenous numeral systems are endangered, indeed often more so than the languages of which they form part. While much progress has been made in documenting indigenous numeral systems, their future as living features of community practice is increasingly in jeopardy. After a brief survey of the range of diversity in Papua New Guinea numeral systems, I concentrate on two particular cases: (a) the base-6 numeral system found in the Yam languages, spoken in the far south of the main island on both sides of the international frontier, and (b) the extended body part systems found especially in many highland languages, though I will concentrate on my own work on Haruai. As a linguist, I am saddened by the loss of linguistic diversity. But communities have the right to make choices about the future of their language, including its numeral system. Such choices are better made if they are based on an informed understanding of the effects of different options.

Keywords: Numeral systems; endangered languages; base-6 numeral systems; extended body-part numeral systems

1. Introduction

The basic structure of this article is as follows.[1] In Section 2 I provide a very brief overview of the variation found in indigenous numeral systems of Papua New Guinea. In Section 3 I discuss endangerment of numeral systems, illustrated by concentrating on the challenges facing two of Papua New Guinea's languages, Komnzo <tci; wara1294>[2] (with a base-6 numeral system) and Haruai <tmd; haru1245> (with an extended body-part numeral system). Section 4 draws conclusions and also provides some material from outside Papua New Guinea for comparison.

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1. The article is a written up version of the author's plenary talk given at the Annual Meeting of the Linguistic Society of Papua New Guinea in September 2022. I am grateful to all discussants for their comments. The following abbreviations are used: 2SG second person singular; IMP imperative; LK linker; ORD ordinal; SIMCVB simultaneous converb.

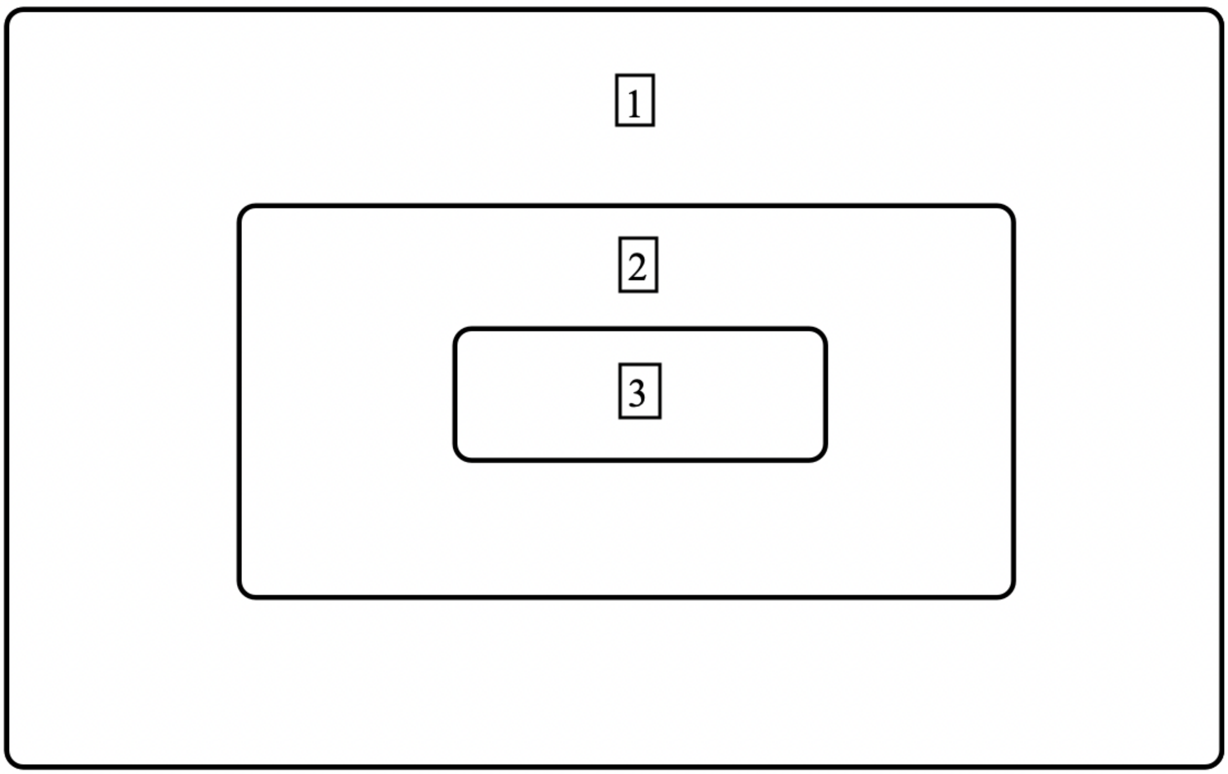
2. At first mention, each indigenous language of Papua New Guinea is accompanied by its 3-letter ISO 639-3 code and its 8-character Glottolog code. Information on the geographical location, genealogical affiliation, and alternative names can be found by searching on the ISO 639-3 code in Ethnologue (Eberhard et al. 2022) or the Glottolog code in Glottolog (Hammarström et al. 2022).

2. Overview of Papua New Guinea indigenous numeral systems

Papua New Guinea, and the New Guinea area more generally, is home to an astonishing variety of numeral systems, and in this section I can only hope to touch the surface of this variation by judicious selection. For further details, readers should consult Owens & Lean (2018) or Comrie (Submitted); both deal with the New Guinea area in general rather than only Papua New Guinea, and Comrie (Submitted) is restricted to Papuan languages.

Simplifying considerably, one can characterize the New Guinea area overall as being divided schematically into three concentric geographic areas as shown in Figure 1, with Papua New Guinea then being the eastern half of the figure.

Figure 1: Schematic representation of major numeral system areas in the New Guinea area



The outer area, labeled 1 in Figure 1, is characterized by the decimal (base-10)[3] numeral system, as familiar from English and Tok Pisin – it is indeed the most widespread numeral base in the world today, found also in languages as disparate as Indonesian, Chinese, and Japanese. There are basic numerals 1–10. Products of the base 10 are expressed by multiplication, e.g. 60 as [6 × 10], e.g. English *sixty*. Intermediate values between the tens are expressed by adding the remainder to the next lower product of ten, e.g. 65 as [(6 × 10) + 5], e.g. English *sixty-five*. Many

[3] My notation "base-n" corresponds to "n-cycle" in Owens & Lean (2018).

languages also have special terms for higher powers ("exponentiation") of the base 10, e.g. English *hundred* 100 (10^2), *thousand* 1000 (10^3). In the New Guinea area, the decimal system is found predominantly on the islands, and predominantly in Austronesian languages – the decimal system is characteristic of the Austronesian language family as a whole outside the New Guinea area – although it is also found in some Papuan languages in the Austronesian-Papuan contact zone, e.g. Yélî Dnye <yle; yele1255>, as in (1) (Levinson 2002: 111–114).

(1) Yélî Dnye

my:oo	y:a	mê	miyó
two.ORD	ten	plus	two

'22'

The first two words in (1) can be interpreted as an instruction to multiply 10 by 2, the last two words as an instruction to add 2 to the result, i.e. [(2 × 10) + 2].

The intermediate area, labeled 2 in Figure 1, is characterized by a system that is easy to understand in terms of counting fingers and hands, toes and feet, though in arithmetic terms it is a little more complex, being quinary (base-5) for numerical values through 20. One counts the fingers from 1 through 4, 5 is expressed as 'one hand'. One then adds four fingers of the other hand to get from 6 through 9, with 10 being 'two hands'. One then proceeds to the feet, adding four toes for 11–14, with 15 being 'two hands and one foot', and finally adding four toes of the second foot to get from 15 through 19, with 20 being either 'two hands and two feet' or 'one person'. In languages that have 'one person', one can then use 20 as a higher base, i.e. the system is overall quinary/vigesimal (base-5/base-20). Products of 20 are expressed as 'so many people', while intermediate values between the twenties are expressing by adding a number in the range 1–19. This quinary or quinary/vigesimal system is characteristic primarily of the lowlands, mainly Papuan languages, though also including some Austronesian languages. It is illustrated by Manambu <mle; mana1298> example (2) (Aikhenvald 2008: 234–242).

(2) Manambu

du-a-mi	nak	sa:p	taba-ti	nəmnəm	viti
person-LK-tree	one	plus	hand-two	plus	two

'32'

In (2), the first two words can be interpreted as an instruction to multiply 20 by 1, the next two words as an instruction to multiply 5 by 2 and add this to the running total, the last words as an instruction to add a further 2 to give the final total [(1 × 20) + (2 × 5) + 2], i.e. [20 + 10 + 2] = 32.

The inner area, labeled 3 in Figure 1, corresponds roughly to the highlands of New Guinea, and is home to extended body-part numeral systems (called "body-part tally systems" in Owens & Lean (2018)), i.e. numeral systems that make use of body parts other than just the fingers, or the fingers and toes. They are a characteristic of highland New Guinea, found in many of its Papuan languages, but apparently not extending to Austronesian, and apparently also not found elsewhere in the world, at least with the degree of elaboration found in New Guinea. There is considerable variation of detail among languages with extended body-part numeral systems (for some of which see Section 3), but the Kobon <kpw; kobo1249> system presented in (3) (Davies 1981: 206–208) is at least not atypical. The count starts typically with the left-hand side, and I will adopt this orientation consistently in presenting the system; in (3), the abbreviations L and R identify left-hand side and right-hand side respectively. More specifically, the count starts with the little finger, then proceeds through the fingers to the thumb for values 1–5. The count then proceeds up the arm, in Kobon identifying six body parts from the wrist through to the collar bone for values 6–11. The sternum (more accurately, the hole above the sternum) is the mid-point of the count, with the value 12. The count then continues down the right-hand side, with the same body parts identified but in reverse order, for values 13–23. It is possible to extend the count by means of a second pass across the body, this time with the right-hand side as the first side, thus giving the values 24–46, and one can proceed further to third and subsequent passes across the body for higher numerical values. Each numeral expression is identical to the name of the corresponding body part, thus *ajɨp* can denote the body part 'biceps', but also the numeral 9. In saying the numeral expression, it is usual to touch the corresponding body part with the forefinger of the opposite hand.

(3) Kobon

little finger	1		23	24		46
ring finger	2		22	25		45
middle finger	3		21	26		44
index finger	4		20	27		43
thumb	5		19	28		42
wrist	6		18	29		41
forearm	7		17	30		40
elbow	8		16	31		39
biceps	9		15	32		38
shoulder	10		14	33		37
collar bone	11		13	34		36
sternum		12			35	
	L		R	R		L

It will be noted that a given body part receives different numerical values, first depending on whether it is on the first or second side of the given pass across the body (for all body parts except the mid-point), secondly depending on the number of the pass across the body. It is possible to distinguish such numerical values by adding *böŋ* to identify the second side, and the expression *ñin juöl adog da* to indication completion of one pass across the body, supplemented by numerals to indicate subsequent passes. Thus, *ajɨp* 'biceps' can in principle indicate 9, 15, 32, 38, and so on, but the expression in (4) explicitly identifies the numerical value 38 by specifying that one pass across the body has been completed (and thus, one is in the second pass), and that the relevant body part is on the second side (the left-hand side on the second pass).

(4) Kobon

ñin	juöl	adog	da	ajɨpböŋ	
hand	pull_out-SIMCVB	back	give.IMP.2SG	biceps	second_side

'38'

The system overall can thus be analyzed as being symmetrical (i.e. using the same body parts on either side of the body – see the discussion of Haruai in Section 3 for an asymmetrical system), as having a base of 23, and as having a mid-point of 12. Most (but not quite all) New Guinea symmetrical extended body-part numeral systems have a mid-point, which means that they typically have an odd number as base, a cross-linguistically highly unusual state of affairs.

In addition to the above three systems that characterize large but specific areas within the overall New Guinea area, there are also some systems that occur more sporadically, either recurring within much of the New Guinea area or restricted to very small areas. Two such systems will now be presented – there are many more.

A system that is found sporadically but frequently in New Guinea, especially in Papuan languages but also through contact in some Austronesian languages, is a restricted system, i.e. one that can only go up to a rather low numerical value, with one particularly frequent such system having 4 as its highest numerical value, as illustrated by the Haruai forms in (5).[4]

(5) Haruai

1	paŋ	
2	mös	
3	mös paŋ	[2 + 1]
4	mös mös	[2 + 2]

The Haruai system is transparently binary-additive, i.e. the numerical values 3 and 4 are expressed via adding 1 and 2, respectively, to the base 2. In some other languages the expressions for 3 and/or 4 are opaque, and the count may proceed somewhat higher, although this is emphatically not possible in Haruai (e.g. **mös mös paŋ* for 5 is decisively rejected by speakers). In all of the New Guinea area languages known to me to have a restricted system, this exists alongside another system that permits the expression of higher numerical values; see Section 3 for Haruai's extended body-part numeral system.

A base that is found only in a restricted area of New Guinea, and apparently nowhere else in the world, is 6 (senary system), attested in the Yam languages spoken on both sides of the international border in the Morehead-Maro region in the southernmost part of the main island of New Guinea. The system is illustrated in (6) and (7) for one of the Yam languages, Komnzo (Döhler 2018: 93–95). In (6), the left-hand pair of columns gives the numbers 1–5, while the right-hand triple of columns gives the forms for 6 and powers of 6. The system is used exclusively for counting yams, and the higher numerical values are perfectly plausible in counting yams for a large feast.

(6) Komnzo

1	näbi	6		nibo
2	yda	6^2	$= 36$	fta
3	ytho	6^3	$= 216$	taruba
4	asar	6^4	$= 1296$	damno
5	tabuthui	6^5	$= 7776$	wärämäkä
		6^6	$= 46656$	wi

4. All Haruai material is from my own fieldwork.

Given the radically different bases between Komnzo (base 6) and English (base 10), the concept of "round number" receives different numerical values in the two languages. The numerals *nibo* through *wi* in (6) are round numbers in Komnzo, but not in English, Conversely, the English round number *fifty* [5 × 10] is not a round number in Komnzo, as seen in (7).

(7) Komnzo

näbi	fta	a	eda	nibo	a	eda
one	thirty-six	and	two	six	and	two

'50' [$(1 \times 6^2) + (2 \times 6) + 2$]

3. Endangered languages and endangered numeral systems

Those working on or with the indigenous languages of Papua New Guinea are, alas, only too familiar with the phenomenon of endangered languages, and this pattern of endangerment is replicated, to a greater or lesser extent, in indigenous languages across the world. Members of a speech community have, of course, the right to linguistic self-determination, including the right to abandon their traditional language in favor of a language of wider currency, but such decisions should always be made on the basis of informed awareness, rather than language loss being allowed to creep stealthily into the community through lack of awareness, let alone being imposed from outside. The community should also be aware that once the traditional language is gone, chances are against its ever being successfully revived, even in the case of well-documented languages. Thus a decision to abandon the traditional language is a decision taken by the current speakers, but with irrevocable implications for future generations.

If anything, indigenous numeral systems are even more endangered than indigenous languages, as illustrated by the various case studies presented in Comrie (2005). A striking instance of this is provided by Japanese, by no means an endangered language, with an estimated 125 million speakers (Eberhard et al. 2022), nearly all literate in Japanese and the overwhelming majority functionally monolingual. Japanese has two sets of numerals, as shown in (8). For the range 1–10, both indigenous numerals and loans from Chinese (so-called Sino-Japanese) are available, with complex rules determining when each set must be used. Above 10, however, only Sino-Japanese numerals are available, having replaced the remainder of the indigenous system.[5]

Japanese

(8) Japanese

	Indigenous	Sino-Japanese
1	hito	ichi
2	futa	ni
3	mi	san
4	yo	shi

[5.] For further details, Martin (1988: 769–772) may be consulted. Some higher indigenous numerals survive in fixed expressions, e.g. *hata* 20 in *hatachi* '20 years old' and *hatsuka* 'the 20th day of the month', showing that the indigenous system did once extend further.

5	itsu	go
6	mu	roku
7	nana	shichi
8	ya	hachi
9	kokono	ku
10	to	juu
11		juu-ichi
20		ni-juu
100		hyaku
1000		sen
10,000		man

In the remainder of this section, I will examine possible endangerment scenarios for two indigenous languages of Papua New Guinea, Komnzo and Haruai.

As noted in Section 2, the Komnzo base-6 counting system is used only for counting yams, i.e. there is a close connection between the traditional numeral system and a traditional cultural activity. A video of this traditional counting practice has been posted by Christian Döhler at <https://vimeo.com/54887315>, and this should be consulted for better visualization of the following brief discussion. In counting yams, the yams are moved from an uncounted pile to counted piles. Each single movement involves two people each carrying three yams, whence the value 6 that is central to the system. A third person counts out loud. Once the single movement has been repeated for a total of 6 times, this establishes a counted pile with value 6^2, and so on through the powers of 6 and products of those powers, as already illustrated in (7). Evans (2009: 331–332) provides a rationale for the choice of the unusual base 6 in this yam-counting procedure. Three is a convenient number of yams for one person to carry: carrying fewer would take more time, carrying more would run the risk of dropping yams and thus ultimately slowing down the process. Two people can conveniently move back and forth between the uncounted pile and the counted piles without getting in each other's way, thus reducing the amount of time that would be taken by having only one carrier, while simultaneously avoiding collisions that would be likely with three or more carriers and might lead to dropped yams or other incidents that would again ultimately slow down the process. The base 6 might thus be regarded as optimal for this particular activity.

As long as the traditional practice of yam counting continues in the community, the indigenous numeral system is reinforced, and this is a good omen for the future of this numeral system, given that it is tied to and arguably optimized for a particular activity. Endangerment of the numeral system would obviously increase if the traditional practice were to be abandoned. And even with preservation of the traditional practice, there is no guarantee that the numeral system will survive, only a diminution of the factors that might lead to its demise. Carroll (2016: 20–22) notes that in two languages from the Kanum branch of the Yam family spoken in Indonesia, Ngkolmpu and Smerky, knowledge of the higher numerals is being lost, with some speakers knowing only 1–6, and only older members of the community remembering the indigenous forms above 36.

Turning now to Haruai, as I first documented it in 1985–1986 and as illustrated in (9), one may note initially that the same body parts are used as in Kobon – the two languages are, incidentally, neighbors, though not demonstrably genealogically related. But there is a crucial difference. In Kobon, the same body parts are counted on the second side of the body, only in reverse order. In Haruai, by contrast, this happens only with the non-fingers on the second side, corresponding to the numerical values 13–18. The count then jumps to the little finger of the hand on the second side, counts through its 5 fingers (values 19–23), then proceeds up that arm. The Kobon system was described in Section 2 as symmetrical because each pass across the body involves the same body parts on either side of the body in mirror-image order, which means that in the shift from one pass across the body to the next pass, the five fingers of the relevant hand are counted twice, once for the earlier pass, once for the next pass. The Haruai system is asymmetrical, specifically since in the shift from one pass across the body to the next pass, the five fingers are counted only once, more generally in that a given pass does not consist of exactly the same body parts for either side but in reverse order.

(9) Haruai

little finger	1			19				37
ring finger	2			20				38
middle finger	3			21				39
index finger	4			22				40
thumb	5			23				41
wrist	6		18		24		36	
forearm	7		17		25		35	
elbow	8		16		26		34	
biceps	9		15		27		33	
shoulder	10		14		28		32	
collar bone	11		13		29		31	
sternum		12				30		
	L		R	R	R		L	L

An interesting question is whether the numerals 19–23 belong to the first (or earlier) pass or to the second (or subsequent) pass. Native-speaker reaction is unequivocal They belong to the first (or earlier) pass. Thus, the first pass finishes at 23, but subsequent passes have only 18 points that are counted, i.e. passes across the body end at 23, 41, 59, etc. – the general formula is [23 + 18n]. The system thus does not have a base in the sense in which English has base 10, Komnzo has base 6, or indeed Kobon can be said to have base 23. This feature of Haruai, distinguishing it from Kobon, was, incidentally, carefully and repeatedly tested with different Haruai speakers in the mid-1980s.

In 2013, I had the opportunity to work with Haruai speakers again, and was surprised to find that the community now used a symmetrical system identical to that shown for Kobon in (3), though with the same Haruai body-part terms as I had encountered in the mid-1980s. Only on one occasion did one older man, when alone with my colleague John Davies and me, spontaneously produce the asymmetrical system as in (9), only to shift back to the symmetrical system once other speakers were again present. This thus shows loss of one feature of the earlier indigenous system, its asymmetry, probably under the influence of the neighboring language

Kobon. This direction of linguistic influence can also, incidentally, be seen in numerous Kobon loanwords in Haruai.

On the 2013 visit I encountered two further modifications of the original system, both probably resulting from the introduction of regular primary education and the increasing monetarization of the economy. One involves truncation of the first pass across the body at 20 (thus, the ring finger on the second side), to produce a system with base 20. The other goes a step further and truncates at 10 (the shoulder on the first side), to match the decimal system of English (and Tok Pisin) and of Arabic numerical notation.

The Haruai system that I documented in the mid-1980s is clearly endangered, and its replacement by a system identical in structure to that of Kobon involves a loss of diversity at the local level. However, the new systems that have arisen (symmetric base 23; base 20; base 10) all have in common that the material that they use is an extended body-part system, making use of body parts other than just the fingers (and possibly toes). Whichever of the systems a Haruai speaker uses, they are clearly following an emblematic practice that identifies them as being from area 3 in Figure 1, and clearly sets them off from those from area 2 or 1. Moreover, there is nothing inherent in traditional counting practices, e.g. of bride prices, that assigns practical preference to one or other of the four current Haruai systems, unlike the situation in Komnzo, where the physical properties of yam counting favor base 6.

Incidentally, a development similar to that just described for Haruai is also described in much more detail for another highland language, Oksapmin <opm; oksa1245>, in Saxe (2012), based on temporally dense observation almost from first contact with Europeans to well into the 21st century. For a broader discussion of the interaction between traditional numeral systems and contemporary Papua New Guinea society, reference should be made to Paraide (2018) and Paraide & Owens (2018).

4. Conclusion and prospects

As a linguist, I deeply regret any loss of linguistic diversity, whether it is the loss of a whole language or even the loss of some substantial part of a language, such as its numeral system. But communities should have the right to make their own decisions on what part of their traditions, including their language, they wish to preserve, and where they wish to shift to more widespread or more prestigious alternatives.

Retention of an indigenous numeral system will be facilitated by its use in traditional practices that are being retained, especially if the numeral system is structurally adapted to the traditional activity, as discussed in Section 3 for the Komnzo base-6 numeral system, well adapted to the yam-counting activity for which it is specialized. Where an indigenous numeral system is not specifically adapted to a traditional activity, as with calculation of bride prices – see the discussion of Haruai in Section 3 – then this reinforcement is absent, and the numeral system is more likely to be endangered. Even if features of the use of the numeral system are considered important as emblems, such as the use of body parts other than the fingers (and toes) in many highland New Guinea languages, then this emblematic feature can be retained even if the numeral system loses its original arithmetic structure (e.g. the more complex traditional Haruai system shown in (9)) and is replaced by a more widespread or prestigious structure or one that better maps onto such innovatory practices as schooling and money, such as the decimal system.

Although I have restricted my attention primarily to languages of Papua New Guinea, I will close by noting a loss of part of the traditional numeral system in my own native language, (British) English. It concerns the numerical value of the term *billion*. Two different interpretations of this word and its cognates in other languages exist in the world today, and have apparently done so since the term was coined in the 16th century. On the long scale, which was current in Britain (and most of the Commonwealth) when I was in primary (elementary) and secondary (high) school, the long scale was used, according to which *billion* denotes 10^{12} (1,000,000,000,000). At the same time, American English used the short scale, according to which *billion* denotes 10^9 (1,000,000,000). During the second half of the 20th century American usage gradually replaced traditional British usage, so that nowadays *billion* denotes 10^9 throughout the English-speaking world. The speech community in which I grew up decided to abandon part of its traditional numeral system. The pattern is similar to that observed with indigenous languages, although the scale of endangerment, through to complete loss of the indigenous numeral system, is much greater in the latter.

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