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Do New Guineans Count?

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Papua,
Territory of Papua
& New Guinea

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Dear Mr. Nolte,

Early research-workers in Papua and New Guinea were faced with many problems that seem remote, if not merely quaint, to their successors. Even if they managed to make friends with the human objects of their interest, they were almost completely unable to communicate with them, except through signs. In these circumstances, there was really no alternative, as one early fieldworker, A.F.R. Wollaston, wrote, but to set about "the task of learning a language with neither grammar, dictionary nor interpreter." To the intrepid explorer and researcher in the first decade of the present century, this did "not seem to be an insuperable difficulty, nor is it perhaps where Europeans and educated people are concerned..." Unfortunately, however, "with Papuans it is a different problem...":

> "The first thing to do - and very few of them would even grasp the idea - is to make them understand that you wish to learn their words. You may point at an object and look intelligent and expectant, but they are slow to take your meaning, and they soon tire of giving information. The facial expression, which amongst us conveys even to a deaf man an interrogation, means nothing to them, nor has the sideways shake of the head a negative meaning to Papuans."

As became a member of the British Ornithologists' Union Expedition of 1909-10, Wollaston persevered at his self-appointed task of establishing a measure of intercultural communication, despite all obstacles:

> "In trying to learn a new language of this kind most people (I imagine) would begin, as we did, with the numerals. But our researches in this direction did not take us very far, for we made the interesting discovery that they have words for one and two only..."

After that, the people he was speaking to continued counting on their thumbs and fingers.

If communication with the Papuans were unusually difficult, research, even into their psychology, was not impossible, for it had already been established by Wollaston's day that "a rough test of an uncivilised man's intelligence is the extent to which he is able to count..." The group interviewed above, therefore, showed few signs of intellectual promise, especially in comparison with another Papuan group, the Motu, in whose case numerical ability and an acute sense of their social station vis-à-vis the white man were finely blended, as Alfred Russel Wallace had reported some years before:

> "Intellectually these people are considerably advanced. They can reckon up to a million. They use the outstretched arms as a unit to measure by. They divide the year into thirteen months, duly named, and reckoned from the new moons. The four winds and many of the stars have names, as well as every tree, shrub, flower, and even each well-marked grass and fern. They prefer white to dark people, and are thus disposed to like and admire the white races."

Mathematics was, therefore, a remarkably important and easily used research-tool on the frontiers of human knowledge well before modern social scientists began to quantify for its own sake. It had a few limitations, however, in the field of sensory perception measurement, as in the experience reported (in 1901) by a member of the Cambridge Anthropological Expedition to Torres Straits who felt that one of his tests of visual acuity might not be appropriate among certain primitive peoples. His test required the people of Murray Island to look through a hole in a screen and count the number of dots they could see. Unfortunately, they could count only in ones and twos, and their compounds: netat (1), neis (2), neis-netat (3), neis-neis (4), neis-neis-netat (5), neis-neis-neis (6). After six, they switched to counting on their fingers and toes. The seeming inaccuracy of their system of numeration, and the movement required when counting on their toes, led Professor Rivers to conclude that "For such people, it is not surprising that a method of testing visual acuity which involves counting should prove to be unsatisfactory..." He hoped eventually to develop a new set of tests capable of universal application, but, following on the work of other scholars, was not prepared to limit the number of dots to one or two. Luck alone might then give the people of Torres Strait a quite undeserved reputation for ocular ability.

Modern Maths

Mathematics is popularly regarded as the most objective of the sciences. Its procedures hold independently of both time and place. Of all the academic disciplines, mathematics seems most nearly culture-free. It has a symmetry and universality to which all the sciences aspire, as the following quotation from the inaugural lecture of Papua and New Guinea's first professor of mathematics makes clear:

> "...mathematics is the universal language for the expression of ideas of quantity and order. It provides a concise and unambiguous way of expressing relationships and making comparisons. Once a mathematical model of a practical problem has been represented in symbols, the powerful techniques of mathematics may be used without the necessity of constantly referring back to the origin and meaning of each symbol."

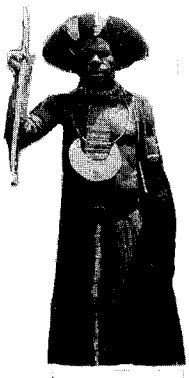
Although some of us may have our reservations as to the objectivity of the more recondite branches of Lobachevskyan mathematics, these generally concern the accuracy or persuasive interest of its assumptions rather than the universality of its procedures. Anyway, simple, everyday arithmetic seems safe enough. Just as Shakespeare's characters always speak in poetry, so most of us count in arithmetic, without thinking about it.

Occasionally, some of us may reflect on the peculiarity of people who measure weight in pounds, stones, hundredweights, and tons (both long and short), while the rest of the world deals much more easily in decimal fractions and multiples of grams. Gradually, however, the decimal is taking over, and the dull uniformity of a base ten counting-system is edging out the more interesting variety of inches, feet, yards, rods, chains, furlongs, and miles. The pounds, shillings and pence system has already fallen in Australia (and in Papua and New Guinea), and our national weight and distance measures seem destined to follow soon. The only light at the end of this tunnel of decimalised uniformity is the prospect of a girl with a bust-measurement of 940 (millimetres, instead of thirty-seven inches), although, at first sight, a waist of 584 (mm., or twenty-three inches) detracts somewhat from one's joy. Indeed, the only firm holdout for non-decimalised individuality, and non-Arabic numerals, is the clock, the public face of which is often dignified with the impressively irregular Roman style of numeration (with its I's, V's, and X's), and a continued tribute to ancient Babylonian counting (by tens to sixty, then by sixties), which ensures that there are sixty seconds in a minute, and sixty minutes in an hour.

In a sense, then, Wollaston, Wallace and Rivers were doing no more than paying tribute to mathematics' public image. They were trying to use the supposedly universal and objective techniques of modern maths to understand their newly-found acquaintances. They were certainly not status-conscious themselves: they did not enquire if Papuans and New Guineans counted, but naturally assumed that people they knew did. What they wanted to know was how (that is, by tens, as we do, or with some other number as their base), and how high, they counted. To paraphrase the two questions more precisely: they wondered, firstly, if a calculating warrior planned to decimate his foes; and, secondly, having heard the Papuans number, whom to number among their friends.

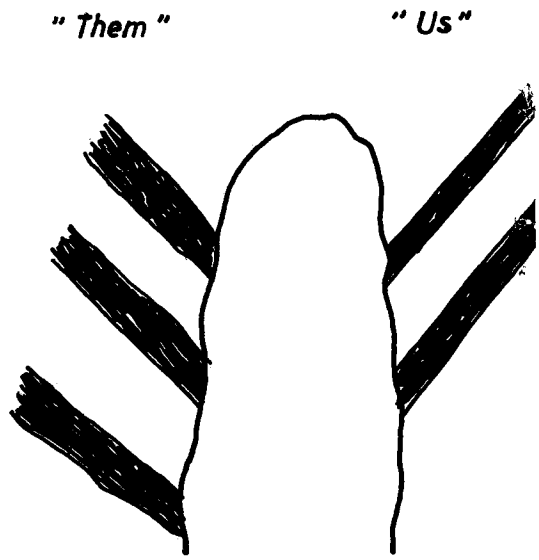
Mathematics and Society

No Papuans and New Guineans were literate in the modern sense at first contact. This did not mean, as more than one hasty wouldbe anthropologist concluded, that they had "no visible method of recording events or numbers, or sending messages..." They did, in fact, have a variety of sophisticated systems for recording transactions, and sending messages independently of their human conveyors.



The number of small bamboo-lengths suspended from a string around his neck indicated the exact number of pig-exchanges in which a Western High lander had taken part. A series of notches in a stick could serve as the traditional version of a cash-book. One group of people inland from the Papuan Gulf, the Parevavo, used to tie a knot in a length of twine for each of its people killed in battle. As each death was avenged, a knot was unravelled. In parts of the Chimbu District, deaths were tallied by painting marks with red pigment on the walls of nearby caves, or on sheltered rock-faces.

Perhaps the most sophisticated scoreboard (or perhaps it was just one of the few that Europeans have noticed) was that employed by the Orokolo people, who live near Ihu on the Papuan Gulf. After a battle, each group would retire to its village to tally up its gains and losses. Firstly, a palm-frond was cut from a sago-palm, and stripped of its outer covering, so as to leave only the soft, inner core. Then, thin pieces of the outer covering of another frond that had previously been dried (selo) were sharpened and stuck into the core: each shaft on the right represented one of "our" men killed; each shaft on the left one of "theirs". These tallies were kept until the score had been equalled, and mutual satisfaction achieved at each group's preservation of its own prestige. Eventually, when equivalence had been achieved, or it was necessary to start a new tally, the old scoreboards were placed in the roof of the men's house for posterity to see.



An Orokolo Tallying Device

The Orokolo used a somewhat similar, but more complicated, version of these war-tallies for more peaceful purposes. Each year, the Motu people from around Port Moresby used to sail across the Gulf of Papua in their twin-hulled, dugout canoes (called lakatois) to exchange their newly-made earthenware pots for sago and logs. These voyages (known as the Hiri) were long and arduous, the transactions at the end ceremonial rather than overtly commercial. There was no formal medium, or even a fixed rate, of exchange. Prestige was acquired through generous giving; face was lost

if the gifts could not be reciprocated. Hence, no public check was kept on how much was given or received, although the Orokolo people used to keep their own private record of their transactions through a (positive and negative) tallying system like that described above. In this case, however, different sizes and shapes of selo represented different gifts received: a long straight piece for a water-pot; a smaller, squatter piece for a pot of similar shape; varying sizes of selo bent back upon themselves (like a loop, with both ends embedded in the newly stripped core) for different sizes of dishes. Face was kept only if the number of shafts on the right-hand side (or "ours" among the Orokolo) exceeded those on the left.

Nonetheless, despite the complexity and sophistication of the foregoing devices, the absence of literacy did restrict the amount, and eventually the accuracy, of knowledge that could be transmitted down the generations. In spite of their rich oral folklore, there is a sense in which literacy alone could have given a history and science to the area's original inhabitants. Without more complex recording devices than the simple one-to-one mnemonics of knots, notches and shafts, genealogies were generally no more than a few generations deep, and speculative thought could not be passed on, and added to, through the years. There was, therefore, no ongoing body of complex mathematical theory in Papua and New Guinea.

However, those early visitors who were surprised that some indigenes could count to ten, and that they had anything worth counting (in the visitors' eyes) anyway, overlooked the internal complexity, and the intricate inter-group dealings, of traditional life. If the Mafulu in the inland of the Central District seemed to have no devices for recording events and transactions, and if many other groups seemed unable to count past two, they were at but one extreme of a continuum. At the other end of the continuum were the Kapauku people of the West Irian Highlands.

The Kapauku have recently been studied by an American scholar, who rather self-consciously opened one of his books (on their traditional economy) with a three-factor explanation of its quantitative bias: as a young student suddenly settled in the remote interior of West Irian for a year, he had measured all he could for fear that mastery of the local language might elude him (and leave him with nothing to show for his trip); the need to acquire economic data to explain parts of his primarily legal and political analysis; and, finally, "the native obsession with quantification, their rather sophisticated numerical system, and their quantitative world outlook."

The Kapauku count by tens, as we do, as far as sixty, and then in multiples of sixty. Their system of numeration is the same as that used by the ancient Babylonians. As recorded, the Kapauku certainly seemed numbers-mad:

> "These people are so fascinated by numbers that they indulge in counting, in recalling precise sums paid in specific exchange transactions, and in discussing these data at any opportunity that presents itself."

The Kapauku seemed, then to be an ideal people for an anthropologist with some experience in statistics and quantification to work among. They had one of the most highly commercialised economies and sets of interpersonal relations anywhere in New Guinea, with cowrie-shells as the medium of exchange. What finally placed the seal upon their reputation for mathematical extremism, however, was their obsessive preference for dental quantification over the appreciation of beauty. To quote "their" anthropologist again:

> "They place value upon higher numbers and larger volume. The emphasis upon quantity may assume forms which come as a shock to the Western observer. My informants when confronted with a magazine picture of a smiling girl failed completely to react to her beauty. Instead they started to count all her teeth."

It has often been observed by the cynically-inclined that British anthropologists tend to find chiefs, and sometimes kings, in the societies they study; their American counterparts find bustling, democratic societies of acquisitive, individualistic, entrepreneurs. The Kapauku, however, must surely be held to be "mainly responsible for the exact data" and quantitative bias of their ethnography. Their "quantitative world outlook" seems only too clear.

Midway between Wollaston's first contacts and the Kapauku - both geographically and mathematically - are the people of the Morehead area in Papua's Western District. Here counting does take place, but in a numerical system, and with a lack of obsessiveness, that distinguish it from the two groups mentioned above. Indeed, the business of counting among the Keraki is carried out through a quite complex division of labour.

The exigencies of the climate, and the nature of their principal staple, taitu (a small yam), make it necessary for the Keraki to live on stored food for much of the year. Before storing, the yams are counted - a custom which seemed to be of comparatively recent vintage when first recorded by an anthropologist in 1936.

The Keraki themselves normally employ a system of numeration with a base of five. Their yams, however, are counted in a perfect six base system imported from, and largely carried out by, the Gambadi and Semariji people from beyond the Morehead River.

The system of counting they employ requires two men, who each pick up three yams at a time from a central pile, and then deposit them together in another place, while one of them, the counter, calls nyambi, nyambi, nyambi ("one, one, one"), for the first six yams, then yenta, yenta, yenta ("two, two, two") for the next six, and so on, until he calls "six, six, six" when six lots of six yams, or one peta, have been set down. Then, the two carriers place another thirty-six yams on the pile (each of the men carrying three yams on six separate occasions), and the silent teller records their placing with a new counter. When six peta (that is, 216 yams) have been placed together so as to form a single storage heap, or a tarumba, the men check the counters before

proceeding to make a second tarumba (that is, a further storage heap of 216 yams), and so on, until there are six tarumba or 6 x 216 yams put away, that is 1296 yams in all, or one dameno. Only then could a gardener be sure that he would have enough to eat until his next harvest was due. His reputation as a proficient horticulturalist remained secure for another year.

After the laborious precision of the above process, a really competent gardener would put even more (uncounted) food aside for eating (much of that counted being intended for seed) - a procedure which the Keraki's ethnographer found "hardly logical" after the painstaking and "surprising accuracy" of the preceding operation.

Many other peoples help each other to count in much simpler ways than the Morehead River people. The Aiome people of the Madang District, for example, count in twenty-threes - along the fingers, then the thumb, of one hand, the wrist, the forearm, the elbow, the upper arm, the shoulder, the hole between the collar-bone and the neck on one side, then the hole at the front between the neck and the collar-bone, then down the other side (that is, the same places in reverse order to the foregoing, from the collar-bone down), calling the names of the various parts of the body they are pointing at on the way. When counting many things quickly, however, they do not use the names of the various body-parts as numbers; instead, one man may count certain objects in pairs, saying omngar o ("these two"), omngar o as he touches them, and his companion marks them off on his own body, and repeats the expression, omngar o.

In several other areas, where people count in fives, tens, or twenties, on their fingers and toes, a man may decide to help a friend out by standing still, and placing his own fingers and toes at his friend's disposal once he reaches twenty. The Mafulu, for example, count basically in ones and twos (with special accumulators whenever the number reached is divisible by five) on their fingers and toes, and cannot, therefore, proceed beyond twenty alone:

1 fida ("one")
2 gegedo ("two")
3 gegedo minda ("two and another")
4 gegedo ta gegedo ("two and two")
5 gegedo ta gegedo minda ("two and two and another")
or bodo fida ("one hand")
6 gegedo ta gegedo ta gegedo ("two and two and two")
7 gegedo ta gegedo ta gegedo minda
or bodo fida ta gegedo ("one hand and two")
8 gegedo ta gegedo ta gegedo ta gegedo
or bodo fida ta gegedo minda ("one hand and two and another")
9 gegedo ta gegedo ta gegedo ta gegedo minda
or bodo fida ta gegedo ta gegedo
10 bodo gegedo ("two hands")
11 bodo gegedov'u minda ("two hands and another")
12 bodo gegedo ta gegedo ("two hands and two")

13 bodo gegedo ta gegedo minda
14 bodo gegedo ta gegedo ta gegedo
15 bodo gegedo ta jovari fida ("two hands and one foot")
16 bodo gegedo ta jovari fidan'u minda ("two hands and one foot and another")
17 bodo gegedo ta jovari fida ta gegedo
18 bodo gegedo ta jovari fida ta gegedo minda
19 bodo gegedo ta jovari fida ta gegedo ta gegedo
20 bodo gegedo ta jovari gegedo ("two hands and two feet").

If the Mafulu wish to express a number as high as eighty-three, for example, five men are required, four of them sitting, according to R.W. Williamson, "with all their hands and feet crowded together...and...a fifth man with a thumb and two fingers of his right hand closed up."

Indigenous Systems of Numeration in Papua and New Guinea

Within the limits of a universal Stone Age technology and the absence of literacy, the cultural (as well as the linguistic) diversity of the New Guinea area before contact was truly bewildering. Every small village or hamlet made its own unique adaption to the local environment; every inhabited part of the area was changed by the local people in a slightly different way (from simply chopping down trees, to digging massive trenches for defence). Very few of the social sciences have yet progressed sufficiently in their investigations of the area to produce even a crude outline of the parameters of its internal variation. As the earlier parts of this "Newsletter" have implied, there is even a wide variation in the ways in which Papuans and New Guineans have structured their systems of numeration. Indeed, we still do not know how many systems there were - many languages have still not been systematically recorded, others are already in process of displacement or quite basic restructuring by their larger neighbours, or the Territorial linguae francae. We cannot even be certain how much particular investigators have contributed to, or obliterated, the apparent range of variation in as evidently an "objective" field as mathematics. As early as 1885, for example, R.H.Codrington, the great pioneer of Pacific linguistics, warned that some indigenes may count on their fingers without speaking, and that the "practice of turning down the fingers, contrary to our practice, itself deserves notice, as perhaps explaining why sometimes savages are reported to be unable to count above four...":

> "The European holds up one finger, which he counts, the native counts those that are down and says 'four'. Two fingers held up, the native, counting those that are down, calls three; and so on till the white man, holding up five fingers, gives the native none turned down to count. The native is nonplussed, and the enquirer reports that savages cannot count above four."

At one stage, it was thought that the type of numerical system used in different broad parts of the New Guinea area might produce a useful key to its linguistic puzzle (which key might, in turn, provide an ordering principle for the large body of data that had been collected). Professor Sidney H. Ray, who accompanied the Cambridge Anthropological Expedition mentioned earlier, propounded a theory that the languages of British New Guinea (now Papua) could be classified into two broad groups: Melanesian and Papuan languages (both of which terms, in their linguistic sense, neither refer to the racial characteristics nor to the Territorial origins of their speakers). Both categories were analytical only (that is, they may have implied a common origin, but both included hundreds of presently mutually unintelligible languages), and it was then unclear whether the Papuan languages were interrelated at all, or just a jumble of languages with no relatives outside the New Guinea area, and perhaps few interrelationships within it.

One of the six criteria that distinguished Papuan from Melanesian languages seemed to be their systems of numeration. The Papuan languages, Ray believed, rarely advanced beyond five in numeration, while the Melanesian languages (which belong to the Austronesian or Malayo-Polynesian family) generally went at least as far as five, and sometimes advanced, by fives, as high as ten or even twenty. In his very first exposition of the theory, however, Ray already had to discount several inconsistencies. Those Papuan languages which his records showed did advance well beyond five were but "apparent exceptions..., ...probably due either to imperfect knowledge, to borrowing from another language, or to imitation." Some of the Melanesian languages, on the other hand, for example Wedau, from the Milne Bay area, showed "traces of a former inability to count beyond three."

Ray's second distinction between the numbering-systems of the two language types was based on the putative Melanesian custom of counting only on fingers and toes, and only rarely on other parts of the body. Papuan language-speakers, on the other hand, were reputed to put their fingers everywhere - on their neck, ears, eyes, nose, elbows, breasts and navels.

Ray's attempt to discover a series of numerical indices for different language types seems now to have been discredited (though many of his other theories, including the primary language division into Melanesian and Papuan languages, and much of his remaining data, are still highly regarded by professional linguists). He was consistent to too small a portion of the New Guinea area's linguistic diversity, which has now been systematised so that it cuts right across Ray's numerical theories by Doctors Wurm and Capell.

Much of Ray's theorising probably rested upon a certain vagueness as to what constitutes a number, or a base. Many language-groups tend to have abstract words for only one, two, and sometimes three, after which they proceed to mark off, and call the names of, parts of the body. Some of the Elema of the Papuan Gulf, for example, (presumably, in this case, an Elema group other than the Orokolo), have abstract words for numbers up to five (in what appears to be a binary system with a special word - never used in multiples - for three):

haroapu (1), oraoka (2), irohio (3), oraoka-oraoka (4), oraoka-oraoka-haroapu (5). If they are going to proceed beyond five, then they use only the first three numbers, and the terms for four and five are changed to the words for those parts of the body they are touching as they count. From three, ticked off on the little (1), the ring (2), and then the middle (3) fingers of the left hand, they proceed as follows:

left hand			right hand	
			27	ukai-haruapu
			26	urahoka-ukai
			25	iroihu-aukai
4	hari	("index finger")	24	hari-aukai
5	hui	("thumb")	23	hui-aukai
6	aukava	("wrist")	22	ukava-ukai
7	farae	("fore-arm")	21	farai-ukai
8	ari	("elbow")	20	ari-aikai
9	kae	("armlet")	19	kae-aukai
10	horu	("shoulder")	18	horu-kai
11	karave	("neck")	17	karave-haukai
12	avako	("ear")	16	avako-kai
13	ubuhae	("eye-ball")	15	ubwauka ("eye").
14	overa	("nose")		

kai, ukai, haukai probably mean "other" or "second", according to the collector of this list.

The Elema system of numeration, like many others in Papua and New Guinea, does not fit into any clear category of numbering-system, unless one has a prior theory as to what constitutes an abstract number rather than a body-part used as a counter, and what a numerical base may be (that is, do the Elema really only count in twos and stop at five, or in twenty-sevens, with a physical representation - a man - of each accumulation of twenty-seven).

Naturally enough, there is a monumental German treatise on the subject of indigenous systems of numeration throughout Australia, the Pacific and black Africa, written by Theodor Kluge, before the war. With the aid of copious references to almost all of the extant bibliography on the subject, he aimed to bring "together everything relevant from the disciplines of Philosophy, Mathematics, Physics and Botany to construct a picture of what a number could be" (my translation). In Kluge's view, numerical systems like that of the Elema, for example, really lacked any true numerical concepts, which can only be said to exist, he argued, when they separate themselves from parts of the body. In the South Seas generally, he felt, the idea of numbers had not properly developed: two generally meant "broken in half", "the other" or "double", all terms that have nothing to do with the development of abstract numerical concepts.

Kluge's work was so impressively scholarly and definitive that it even expressed doubts as to the reliability of the (sometimes inconsistent) data tendered by the indigenes to earlier writers. Against a work that began with an attack on the anti-intellectualism of Schiller, William James, Dewey, Bergson, Nietzsche, Croce, and Berdjajew, and then went on to Kant, who can but say that the original Papuan and New Guinean informants probably were wrong.

For the remainder of this section of the "Newsletter", I shall try to outline some of the principal types of numerical system I have been able to discover both in the literature and from individual Papuans and New Guineans. The information presented does not pretend to be comprehensive - at least seven hundred languages would need to be studied for that - nor to be more accurate than my sources. It does, however, cover probably a majority of the principal mathematically different variants to be found in the Territory. As the data cannot be geographically or linguistically arranged, it has generally been set out in ascending order of the various systems' numerical bases. Naturally enough, there are no one base systems, for they would scarcely be numerical systems at all, while the majority are probably based on units of five, ten or twenty (that is, fingers and toes), or other anatomically derived totals (for example, the Elema and Aiome systems outlined above). There is, however, considerable variety in the range of bases used.

Many Papuans and New Guineans employ an arithmetic system with the same (binary) base as that of an electronic computer. While I.B.M. spends much time and effort in teaching binary arithmetic to wouldbe computer-programmers, many Papuans and New Guineans who count naturally by twos work away at school learning how to operate in tens, as we mostly do.

A number of language-groups have quite obvious binary systems (that is, one can tell that they are binary from the sounds employed alone). The Kiwai and the Tugeri of Western Papua both operate exclusively in twos, but, as can be seen from the examples, counting can become a fairly cumbersome procedure after a comparatively short time:

	Tugeri	Kiwai
1	zakudĕkĕ	nao
2	inèkĕ	netowa
3	inèkĕ-zakudĕkĕ	netowa nao
4	inèkĕ-inèkĕ	netowa netowa, etc.

Some groups, like the Elema (above), operate primarily in twos, but have a special word for three, while others, for example the Kuman of the Chimbu District, work in twos to five, for which they have a special word, and then again to ten, after which they work in tens (numbered internally by twos):

Kuman	
1	suara
2	suo
3	suo ta ("two and something")
4	suo wa suo ("two then two")
5	suo wa suo ta ("two then two then something") or ongun suwara ("one hand")
10	ongun suo ("two hands").

Nowadays, many Kuman-speakers count in Pidgin (using a decimal system) once they get past three.

The Kamano of the Eastern Highlands now use a part-binary, part-quinary (that is, base five) system of numeration rather like that of the Kuman. Traditionally, they tended to tick off numbers on their fingers, or by moving small sticks from one pile to another, rather than count aloud. However, they did have words for one (ngoke) and two (tare) which enabled them to construct three and four from combinations of the two preceding numbers: tare ki ngoke ("two and one"), and tare ki tare ki ("two and two"). At five, however, they switch to nzatiga ("hand"), and construct ten (nzantare ma'a: "hand two finished"), fifteen (nzantare ma'a nzatiga: "hand two finished hand"), and twenty (naka tare nzantare ma'a: "leg two hand two finished") on a quinary base. For numbers that are not divisible by five, they use quite lengthy sentences to describe how many ones and/or twos the number they want is from a multiple of five. Thus, one of several ways in which seventeen can be described, other than by pointing along the speaker's fingers and toes, is:

nzantare	haneno	nzatiga	haneno	tare	eburi'nia
hand	two finish	five or hand	finish	two	take

while nineteen can be expressed as:

nzantare	haneno	najana	ngoke	ome'aterenea
hand	two finish	hand	one	leave out .

Although Professor Ray speculated that some Melanesian languages may possibly have had a base of three at some time in the past, only one base three system has been recorded as being in everyday use in Papua and New Guinea, that employed by the Bine of Papua's Western District:

Bine	
1	iepa
2	neneni
3	nesaio
4	nesaio iepa
5	nesaio neneni
6	nesaio nesaio
7	nesaio nesaio iepa
8	nesaio nesaio neneni
9	nesaio nesaio nesaio, etc.

Although I have been unable to find any pure base four systems of numeration, the people of at least two areas of Papua and New Guinea do sometimes count in units or quantities of four.

Normally, the Mailu of Eastern Papua count on their fingers, in a base ten system. Many of their foods, however, are counted in quantities of four, and they have special terms (apart from their normal plurals) for four taro, four sweet potatoes, four fish or four coconuts. In the case of coconuts, they go one further, and have special words for:

4 coconuts: 1 gau
6 coconuts: 1½ gau: 1 bara
8 coconuts: 2 gau: 1 areba,

and, according to Saville, for:

12 or 16 coconuts: 3 or 4 gau: 1 baiva.

The people of the Duke of York Islands, near New Britain, also count coconuts, taro and yams in fours, and here the terms for groups of four nuts seem to be directly derived from their normally quinary system of numeration:

Duke of York Islands			
1	ra	6	limadi ma ra
2	ruadi	7	limadi ma ruadi
3	tuludi	8	limadi ma tuludi
4	watdi		or ru wat ("two fours")
5	limadi	9	limadi ma watdi

10 noina
11 noina ma ra
20 ru noina ("two tens")

4 coconuts: ra kuren
8 coconuts: ru kuren
12 coconuts: tula kuren
16 coconuts: wat na kuren
20 coconuts: lima kuren
28 coconuts: limadi ma ruadi kuren
40 coconuts: kabinaina kuren
80 coconuts: rua kabinaina kuren
400 coconuts: mara na kabinaina.

Probably a majority of Papuans and New Guineans do most of their counting on their fingers and toes. They manage to do even this, however, in a variety of different ways.

Quite a few language-groups count in fives, much as the Kamano (above) do, although all of those recorded in Papua and New Guinea have a special word for twenty, usually the same as the term for "man" or "one man is dead (or finished)" in their vernacular. Ray tended to classify these systems of counting as

vigesimal, because, from twenty on, they generally proceed in multiples of twenty (counted internally in groups of five). Unlike the purely quinary systems of numeration found elsewhere in the Pacific, none of the languages of Papua and New Guinea that I have seen recorded counts twenty purely as four fives (as a quinary system would). It seems futile, however, to distinguish too finely between the various kinds of systems. Most of their bases are, in fact, anatomical (specifically, digital) rather than numerical, and many of them count through lengthy and circumlocutory descriptions of hands and feet rather than in simple numbers. The Wedau people of the Milne Bay District, for example, employ the following part-quinary, part-vigesimal system of numeration:

	Wedau
1	tagogi
2	ruag'a
3	tonug'a
4	ruag'a-ma-ruag'a
5	ura i qa ("hand is finished").

The numbers from six to nine (inclusive) are constructed by saying ura g'ela ("hand other") and then adding the first four numbers above, for example:

8 ura g'ela tonug'a ("hand other three").

Ten is ura ruag'a i qa ("hands two are finished"), and the numbers eleven to fourteen are counted on a foot(ae):

12 ura ruag'a i qa, au ae ruag'a ("hands two are finished, on the foot two").

Fifteen is ura ruag'a i qa, ae tagogi i qa ("hands two are finished, foot one is finished"), and then sixteen to nineteen are counted in the following form:

16 ura ruag'a i qa, ae tagogi i qa, au ae g'ela tagogi ("hands two are finished, foot one is finished, on foot other one").

Twenty is rava tagogi i irag'e ("man one is dead, that is, finished").

The Suau people, also from Milne Bay, and the Sabeng of Siassi Island in the Morobe District, count in fives to twenty too, but with a special word for ten on the way, and then continue on in multiples of twenty:

	Suau	Sabeng
1	esega	ez
2	rabui	ru
3	haiona	tol
4	hasi	pang
5	harigigi	lim
6	harigigi -esega	lim be ez
7	harigigi-rabui	lim be ru
	... and so on to	
10	saudoudoi	sangauul
11	saudoudoi-esega	sangauul ve ez
	... and so on to	

16	saudoudoi-harigigi-esega	sangauul lim be ez
	... and so on to	
20	tau ("man")	tarnot ("one man")
21	tau esega	tarnot ez
	... and so on.	

Thirty in Sabeng is tarnot e sangauul, fifty is tarnot ru sangauul, while one hundred becomes tarnot lim (or, as in English, a new expression can be introduced: dingding ez).

The Domara people, a third eastern Papuan group, count in fives to (but not including) ten, and between numbers divisible by ten, in an otherwise decimal system:

Domara

1	ombua	6	lili-omo
	(in which the suffix-bua means "only")		
2	awa	7	lili-awa
3	ais'eri	8	lili-ais'eri
4	taurai	9	lili-ataurai
5	ima	10	nana or nana-om
20	nana-awa	60	nana-liliomo
30	nana-ais'eri	70	nana-liliawa
40	nana-taurai	80	nana-liliais'eri
50	nana-ima	90	nana-liliataurai
	100	nana gabana ("tens are finished").	

To my knowledge there is only one counting-system in use in Papua and New Guinea with a base between five and ten, that used by the Gambadi and Semariji people as described above, and there seems to be but little obvious cause to expect to find any others (although, true to their reputation for limitless diversity, some Papuan and New Guinean will probably produce one).

There are, again, several different types of decimal systems. The Suku of the Mt.Cameron area, for example, use a binary system with a special word for ten (mataki, which can also be used for "plenty"), while the Orokolo use a decimal system that is only partially dependent upon their fingers and toes:

Orokolo

1	haraopo ("thumb")
2	elahokaila ("index finger with") (ila means "with")
3	irihoila ("middle finger with")
4	hari-ila ("ring finger with")
5	hue ila ("little finger with")
6	aukava ila ("upper wrist with")
7	palae ila ("lower wrist with")
8	ari ila ("elbow with")
9	kae ila ("arm band with")
10	horo ila ("shoulder with") or mai ukai ukai ("hand one side other side", said while opening and closing both hands simultaneously).

11 mai ukai ukai haroapu, and so on.

The Orokolo system of numeration seems to be almost unique among Papua and New Guinea's decimal systems in its departure from the usual fingers or fingers-and-toes methods of decimal counting. In another respect, however, it is quite typical of all but a handful of Territory systems in that it employs a system of what Ray called "imperfect decimal notation".

Briefly, Ray (and other linguistis) divided the decimal systems of Papua and New Guinea into two broad types: the imperfect, and the pure, decimal systems of notation. The imperfect type of system, in turn, has many variants, but in all of them the numbers of the second hand (or five) apart from ten do not have their own independent names (as in a system of pure decimal notation). The numbers from six to nine (inclusive) are derived, in several different ways, from the first five numbers: by addition, as in the (primarily quinary) system employed by the Domara people, of one, two, three, and four, to five, to make six, seven, eight, and nine respectively; by multiplication of earlier numbers and addition, as in the system employed by the Motu people of Papua's Central District; or by multiplication, and subtraction, as in the Hula system (also from the Central District):

Motu

1	ta
2	rua
3	toi
4	hani
5	ima
6	tauratoi ("twice three")
7	hitu
8	taurahani ("twice four")
9	taurahani-ta ("twice four and one")
10	gwauta
11	gwauta-ta
	... and so on to
20	ruahui
	... and so on to
31	toi-ahui-ta
	... and so on to
100	sinahu-ta
101	sinahu-ta mai ta (mai means "with")
	... and so on to
1000	daha ta
	... and so on to
2000	daha rua
	... and so on.

Hula

1	ka, kopuna
2	lualua
3	koikoi
4	vaivai
5	imaima
6	kaula-koi ("double three")

7 mapere-kaula-vaivai ("unit less than double four")
8 kaula vaivai ("double four")
9 mapere-ka-gahalana ("unit less than one ten")
10 gahalana.

The Tagula system of numeration from Sudest Island in eastern Papua, is one of the few pure decimal systems in the New Guinea area (that is, it has no internal repetitions, multiplications, subtractions, or additions, before ten is reached). Its multiples of ten are also apparently built upon the first ten numerals:

Tagula			
1	rega		
2	reu	20	yairo
3	goto	30	yeto
4	kovaru	40	yavaru
5	golima	50	yolima
6	koona	60	yoona
7	apiru	70	yapira
8	vawa	80	yooa
9	vatchiu	90	yosuva
10	ewara	100	tangaro
11	ewara rega	102	tangaro neu.

After ten, I know of only one system of numeration with a base of less than twenty, that of the Jibu people from the headwaters of the Binaturi River, who use a base of nineteen. As the Jibu system operates in a rather similar manner to those systems with a base of more than twenty, it can more conveniently be discussed below with them.

There is, finally, one last system of fingers-and-toes numeration that requires mention here, the vigesimal. All of the known vigesimal systems in Papua and New Guinea, however, have been discussed before: those that are essentially quinary in character with special words for twenty and for multiples of twenty (but not for ten), for example Wedau; and those that are quinary but for the inclusion of a special word for ten, for example Suau and Sabeng, on the way to twenty (which, in this case, is not related to the term for ten). There are no base twenty systems of numeration in Papua and New Guinea with a separate term for every number between one and twenty, although several systems, like that of the Kamano, may sound that way to alien ears until spelt out slowly or translated.

There is a special group of numbering-systems, with seemingly off-beat bases, that are counted out by pointing at different parts of the body. They are all at least anatomically symmetrical in that they progress up one side of the body, and down the other, touching the same places (in reverse order) on the way, calling the name of each body-part as they go. The following systems (and the Aiome system described earlier) are examples of this type, and should be read down to the midpoint, then up again to the end (or base-number):

Jibu

1	little finger	19
2	ring finger	18
3	middle finger	17
4	index finger	16
5	thumb	15
6	wrist	14
7	inner elbow	13
8	armpit	12
9	nipple	11
	breastbone	
	10	

Namau

left hand		right hand
1	little finger	23
2	ring finger	22
3	middle finger	21
4	index finger	20
5	thumb	19
6	wrist	18
7	forearm	17
8	elbow	16
9	shoulder	15
10	side of neck	14
11	breast	13
	chest	
	12	

Telefolmin

left hand		right hand
1	little finger	27
2	ring finger	26
3	middle finger	25
4	index finger	24
5	thumb	23
6	wrist	22
7	forearm	21
8	elbow	20
9	bicep	19
10	shoulder	18
11	neck	17
12	ear	16
13	eye	15
	nose	
	14	

Gende

left hand		right hand
1	little finger	31
2	ring finger	30
3	middle finger	29
4	index finger	28
5	thumb	27
6	forearm	26
7	elbow	25
8	lower bicep	24
	(armband)	
9	upper bicep	23
10	shoulder	22
11	hollow at	21
	base of neck	
12	side of neck	20
13	ear	19
14	temple	18
15	eye	17
	nose	
	16	

There is some doubt whether the four systems outlined above, and the Aiome system outlined earlier, are really numerical systems at all. It seems likely that these groups use their bodies only as counters or tallies. A man from Telefolmin (in the distant inland of the West Sepik District), for example, does not say "neck" in his vernacular when he means eleven or seventeen; rather, he will indicate on his body just where he is up to in counting, and then call "neck" to confirm the point. The Namau (from the Purari Delta on the western side of the Papuan Gulf), the Gende (from the mountains between Madang and the Chimbu District), and the Aiome people at least normally count in twos (and build larger numbers out of ones and twos), and resort to counting on their bodies only when the binary system becomes too cumbersome. Different observers have even recorded totals for the Namau body-counting method: to twenty-three (as above), or to twenty-five (as above, but with the addition of the fold at the base of the thumb). Although the Namau count on their bodies, then, their word for "elbow" does not mean eight or sixteen (or even nine or eighteen),

although a finger of one hand pointing at the elbow of the other arm can, in process of getting there, give a visual impression of just where the counter is up to. To reinforce the argument, the Jibu have been recorded as using the same word, kuraiepa, when bending fingers two to four and the thumb on the way up, and quite different words on the way back. Like some groups I have seen, they probably count "and another, then another" (or an equivalent phrase) on some occasions, and get their meaning across, and at other times switch to calling the names of particular body-parts for effect, or clarity.

Finally, a Jibu counter, for example, does not express twenty in the form 19 (or one man finished) + 1. He may show that he has reached twenty by passing on from one man to another (that is, he may use nineteen as a visual base), but then he starts again from "little finger...". In a sense, then, these systems seem to operate as modular systems. Clocks, for example, have a modulus of twelve: you cannot tell by looking at a normal twelve-hour clock whether it is, say, nine a.m. or nine p.m. (there is no hand to add up quantities of twelve hours as the minute hand adds up quantities of sixty seconds, until it reaches sixty itself, when it begins to operate in a modular fahsion too). The foregoing may, therefore, be systems with a modulus of nineteen, twenty-three (or twenty-five), twenty-seven, and thirty-one respectively although, visually at least, they can be used to accumulate these quantities (and use them as bases when proceeding on).

One last system, that of the Daribi of the Karimui area, on the southern fringes of the Eastern Highlands and Chimbu Districts, may help cast light on the above. The Daribi, too, normally count in twos, but do not have expressions for more than two as most binary-system operators do. When they count large quantities, they also count on their bodies, saying me si, me si ("and two, and two") as they proceed along the fingers of one hand to the base of the thumb (where they count two), then to the forearm, the elbow, the bicep, the shoulder, the collar-bone, and then down the other side. Not only do they not have terms for numbers greater than two, nor do they call the names of the various body-parts as they proceed, but they may reach any one of the range of totals between twenty-six and thirty at the end. In short, the Daribi seem to have a system of counting with a modulus of two, and can express higher numbers only by showing their audience a pile of sticks (one stick for each unit counted) on the ground, or by ticking off the various places on their bodies to show how many they are up to.

Conclusion

In a sense, the foregoing does not require a conclusion. It is an almost self-evident datum on the cultural presumption of many of Papua and New Guinea's European visitors on the one hand, and of the immense variety, and complexity, of a congeries of cultures that are too often lumped together, and too easily dismissed, as "primitive" or "traditional", etc. on the other.

A great many of the systems of numeration described above no longer exist, or are at least no longer widely used. Just as they originally emerged as part of man's early struggle to survive (in order to ensure that adequate quantities of food were conserved for an off-season, for example), and then to seek to change his environment (through ritual, or the gradual accumulation of human or physical resources for a task), so they are now being supplanted by the decimal system of the emerging Pidgin folk-culture, and the international culture of modern science and technology. In the process, curiously little attention has been paid until very recently indeed to the problem of whether, and, if so, how, to build a modern maths. course on the past (for example, through using local counting-systems as examples, perhaps even as the starting-point, in multi-base arithmetic).

Much of the data analysed above, however, needs to be treated with some caution. Most of it was, after all, collected by Europeans, who, in the process of collecting data, often changed it, or perhaps misheard. Just as some scholars have queried other writers' findings (and, by implication at least, the reliability of their informants) in their books, so an agressive questioner could, for example, force a group of Papuans known as the Awaiama to count to twenty as he thought they should. The result of his research, which has been published, was a list of numbers up to twenty, none of which from five on was ever given to him twice in the same order. The numbers he had recorded after five, he later hypothesised, were "either borrowed or fictitious". The same man persuaded the Dabu people to count as high as they could go. Again, he found, that they could "really only count to five" after which they tried, with much imagination, to manufacture compounds. There are many references in the extant literature, too, to certain numbers being "inconceivable" to particular indigenous groups, and others to people who counted to a certain number, then, bored at such a pointless exercise, suddenly said"many". Quite a few systems of numeration have been recorded by researchers in which a Papuan and New Guinean rid himself of an irritating interrogator by trifling with him, and composing such numbers as "many plus one" in the vernacular. In some cases, Papuans and New Guineans were simply being asked to count in ways, or to numbers, which they had never previously had occasion to employ.

In the end, an intelligent Papuan and New Guinean was not allowed to win: if he improvised in a novel situation, by "manufacturing" a new number through a compound, or representing it, perhaps physically, in some other way, he was only pretending, or perhaps being deceitful. If he failed to improvise, he was unintelligent and unimaginative (and his personal failing became that of an entire language-group, or his putative race). Left alone, however, as the systems outlined above show, Papuans and New Guineans were able to count to the extent required for survival, and to the limits of intellectual speculation in a non-literate society. In each case, it needs to be remembered that the seemingly rigidity and precision of many of the foregoing systems when written down, is but a tribute in reverse: to the skill with which their various employers improvised, and manipulated them, in daily life.

Yours sincerely,

Edward Wolfers.

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