Chapter 2
The Languages Studied by Lean and his Analysis of Counting Systems

Kay Owens and Glen Lean

Abstract The complexity and diversity of the languages of the Melanesian region are outlined in terms of their linguistic classification. The languages are divided into Austronesian (mainly Oceanic) and Non-Austronesian categories. Lean attained data from 883 of the 1 201 languages recognised in the 1980s, that is 74% of the languages. The trustworthiness of this book lies largely in the methodology meticulously undertaken by Lean in his study. This chapter provides details of the methodology and data sources that were used. In particular, the extensive nature of his data collection from first contact to field visits and students completing questionnaires are justified and presented as strengths of this book. Some limitations are discussed together with alternative ways of describing counting systems and the reason for selecting Salzmann's (1950) cycle system. In analysing systems, Lean has used the frame pattern (basic number words or morphs, recorded as numerals, from which other number words are formed), the cyclic pattern which is based on the frame words that are repeated in forming new number words, and the operative patterns which are the patterns for generating new number words. In addition, Lean recorded any body parts used for tallying in order to determine the overall nature of the counting system.

Keywords Alternative classifications of counting systems • Austronesian and Non-Austronesian languages • Counting System Questionnaire • Frame patterns in number systems • Operative patterns in number systems • Cyclic patterns in number systems • Digit tally systems • Body-part tally systems • Melanesian languages • Oceania • Papua New Guinea

Introduction

After arriving in Papua New Guinea (PNG) in 1968, Lean became fascinated that his students had multiple ways of counting and he began his journey to collect as many of the counting systems from the languages of PNG as he could and to categorise them in a useful way. Lean continued to collect data on PNG natural language numerals and counting systems from both primary and secondary sources until 1988. At the same time, he became aware that these data might contradict current theories of how counting systems developed and what in fact were key concepts in number. Having students from across the Pacific, he began to realise that Oceania languages could add to this story and he pursued that information when he left PNG in 1989.

K. Owens (✉)
Charles Sturt University, Dubbo, NSW, Australia
e-mail: kowens@csu.edu.au

G. Lean

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The documentation of the accumulated data began in 1985 and a final revised version was completed at the beginning of 1991: this material is held as a counting system database at the Glen Lean Ethnomathematics Centre and was available on a website until recently. In all, data were acquired on the numerals, counting and tally systems of 532 languages, or just over 70% of the total languages of Papua New Guinea, then regarded as 750. Generally speaking, the languages for which it was difficult to obtain data were those with 500 speakers or less; in the Madang Province alone some 93 languages fall into that category. In the ensuing years, SIL (Summer Institute of Linguistics) and others have determined many more languages identified by the people as distinct languages. In Lean's work he had the difficult task of collating often incomplete and differently spelt data from informants on the Counting System Questionnaire (CSQ). Many came from different villages and subsequently many new languages have been identified since Wurm and Hattori's (1981) *Language Atlas of the Pacific Area* which Lean used. Owens also found that variations occurred even between villages and within the same village of the same language from her studies after 2000. Both Lean's and Owens' informants varied in their knowledge of their village language and the degree to which languages such as the lingua franca Tok Pisin and neighbouring languages influenced them. While some detail may be lost, Lean tried to select the best representation from his CSQ sources. It is not possible to compare new data with his original raw data as it is no longer available. For that reason, the language naming from Wurm and Hattori has been used in this book knowing that the Ethnologue provides additional languages. If we attempted to revise the language names, the integrity of Lean's work would be lost as he provided extensive comparative data between early sources, more recent sources and CSQ data. However, many of the languages that are now identified were dialects so a person familiar with the villages, recent changes in village migrations and marriages, and commonly used language names may be able to determine if the data should be given another language name. Examples of this analysis may be found in Appendices B and C of this book.

Details of Lean's Methods and Language Sources

Lean collected data from a large proportion of known languages. Thus out of a total of about 720 Non-Austronesian (NAN) languages (see Chapter 1 for more details), he acquired data for 430 or about 60%. The detailed summary of acquired data is provided in Table 2.1. The distribution of the NAN languages and their phyla are shown in Table 1.1 and Figure 1.2.

Table 2.1
The Number and Percentage of Acquired Language Data in Each NAN Phylum

NAN Language Phyla	Number of Acquired Language Data	Percentage of Languages
Trans New Guinea Phylum	298	>60%
Sepik-Ramu Phylum	44	45%
Torricelli Phylum	26	54%
East Papuan Phylum	23	100%
West Papuan Phylum	10	77%
Sko Phylum-level Stock	6	75%
Arai Phylum-level Family	6	100%
Geelvink Bay Phylum	3	50%
Kwomtari Phylum-level Stock	4	80%
East Vogelkop Phylum-level Stock	2	67%
Amto-Musian Phylum-level Family	2	100%
Isolates	6	75%

Note. Wurm (1982) gave 27 languages for the East Papuan Phylum but 4 were extinct by 1990 and for the West Papuan Phylum, Wurm gave 24 but with 11 of these spoken in North Halmahera, Maluku Islands, Indonesia, Lean only considered 13, of which he had data for 10.

The Trans New Guinea Phylum covers most of PNG and West Papua with small areas on the north for other phyla with the East Papuan in pockets of New Guinea and Papuan Islands and Island Melanesia.

Of the 38 AN languages shown in Table 2.2 for West Papua, 33 are non-Oceanic and the remaining 5 are Oceanic. All other languages are Central/Eastern Oceanic in the excluded areas. Of a total possible 479 AN languages (see Chapter 1 for more details), data have been acquired for 453, or about 95%. Appendix E provides Ross, Pawley, and Osmond's (2003) Proto Austronesian and Proto Oceanic tree for this region.

Table 2.2
The Number of Acquired AN Language Data Given by Cluster within Countries and Percent for Each Country

Country # Clusters	No. of AN Languages For Which Data Were Acquired	Percentage of Known Languages
A. Papua New Guinea	188	91%
1. Admiralties Cluster	24	
2. Western Oceanic		
2.1 North New Guinea Cluster	78	
2.2 Papuan Tip Cluster	41	
2.3 Meso-Melanesian Cluster	64	
3. St. Matthias Group	1	
B. West Papua	38	97%
Oceanic Austronesian	5	
Non-Oceanic Austronesian	33	
4. Central/Eastern Oceanic		
C. Solomon Islands	56	100%
4.1 Southeast Solomonic	22	
4.2 Eastern Outer Islands	6	
D. Vanuatu	105	100%
E. New Caledonia	28	100%
F. Fiji	2	100%
G. Rotuma	1	100%
H. Polynesia (see note)	23	96%
I. Micronesia	12	67%

Note. 1. Language clusters are not restricted to the borders of the countries in this region so it is not perfect to place the clusters under the countries or the countries under the clusters but the table provides some indication of the clusters and their locations.

2. The total number of languages regarded as Polynesian is 36; 22 languages are spoken in "Triangle Polynesia" and 2 others are situated in Micronesia. The remaining 12 languages are dotted throughout Island Melanesia and are included in the figures for Papua New Guinea (3), Solomon Islands (5), Vanuatu (3), and New Caledonia (1). These Polynesian languages found in Melanesia, plus the two in Micronesia, are known as the "Polynesian Outliers".

Combining the AN and NAN languages, there was a total of approximately 1 500 languages recognised as spoken in the region under consideration in 1980s. Lean acquired data for 1 157, 72%, which is a substantial proportion on which to develop his thesis.

Papua New Guinea

The sources of a particular set of numerals are often numerous and at other times very limited. Lean documented the data sources at the bottom of each data table. For some languages, he gave more than one table because the counting system data for some languages was quite varied. This detailed information

upon which Lean's thesis was developed were given in the appendices of his thesis with a few hard copies of his original collation available in libraries in PNG and elsewhere. The sources are basically of two types: primary and secondary; each of these is discussed below. However, the data sources will be included in this book when referenced in the discussion in text or in Appendices B and C.

Primary sources. The primary sources are divided into four main groups. The first group comprises Lean's field notes which were taken in two different sets of circumstances. There are those field notes taken from informants living in villages which he visited. One-to-one interviews were held, wherever possible, with an older member of the village, usually, though not always, male. The language used was invariably Tok Pisin and he had no records of ever having to resort to an interpreter in the case, say, where an elderly informant did not speak Tok Pisin. Prior to 1980 notes were taken during the interview; subsequent to 1980 the interviews were recorded on a portable cassette recorder and the relevant material was later transcribed, normally using Roman orthography, from the tape within a day or two of the interview. From his first field trip in 1968 to his last in 1987, he had records of interviews with informants from 35 villages in eight provinces. The second set of circumstances in which he acquired field notes was when informants, particularly those living in relatively remote areas, visited Lae and he was able to arrange an interview with them. He had records of 29 interviews which fall into this category.

The second main group of primary sources, which in fact forms the major part of the complete database for PNG, comprises questionnaires given to three different populations (see Appendix A). First, there are those completed by incoming students at the PNG University of Technology during the period 1968 to 1983; these account for a total of 1 200. Second, students at four National High Schools (Sogeri, Aiyura, Keravat and Passam) completed questionnaires in 1982, 1984, and 1986; these account for a further 1 022 questionnaires. Third, in 1985, copies of a slightly revised questionnaire were sent to headmasters of 1 700 Community (primary) Schools in all provinces of PNG. In each case the headmaster was asked to assist in the completion of the questionnaire with an adult who spoke the local vernacular (in general, a single rural community school serves a single language group). These account for an additional 302, giving altogether a total of 2 524 usable, completed questionnaires.

The third group of Lean's primary sources comprises unpublished material gathered during the Indigenous Mathematics Project (IMP) during the period 1976 to 1979. The IMP was established in 1976 by the PNG Department of Education under the directorship of Dr David Lancy. The research phase of the project was primarily concerned with studying aspects of children's cognitive development and, in particular, possible cultural influences. In association with the latter, linguistic and anthropological data were collected at each village test site and these data usually consisted of information about the vernacular classification (or taxonomic) systems used in the society together with information about its counting system. Much of this information has subsequently been published (for example, Carrier, 1981; Kettenis, 1978; Lancy, 1983; Saxe, 1979, 1981a, 1981b, 1981c, 1982; Smith, 1978). The unpublished material deriving from the IMP comprises two sets of questionnaires: one by Lancy sent to Grade 10 students and a second by Deibler sent to Summer Institute of Linguistics (SIL) members working in the field each of whom was asked to provide details of the counting system of the language on which they were working. Altogether a total of 238 IMP questionnaires were made available for this study.

The fourth group of unpublished primary source material derives from survey word lists compiled by members of SIL. The PNG Branch of the Institute was established in 1956 and is concerned primarily with Bible translation and literacy. Its members, all of whom receive training in linguistics, have studied in considerable detail several hundred PNG languages; in addition, they have surveyed many more. The SIL library, at Ukarumpa in the Eastern Highlands Province, holds an estimated 500 completed and unpublished Standard Survey Word Lists of various languages from all provinces of PNG (there were 19 provinces until 2013 when two new provinces were made and more recently Bougainville became an autonomous region). The Survey Word List in use after 1965 contains 170

lexical items and 20 standard sentences. The completed Word Lists included data on the numerals 1 to 5, and 10 (and often further numeral data added by the surveying linguist). A complete search of these materials in the period 1984 to 1986 yielded a total of 362 Word Lists which contained some numeral data on various languages spoken in each of the PNG provinces.

In addition, Lean's questionnaire (Appendix A) was modified as an activity by Kaleva and other lecturers for the University of Goroka (UoG) students and by Owens during interviews with villagers. These data are interwoven as needed in this book. During Owens and Kaleva's measurement study from 2006, counting data were included in some reports by UoG students (studying Mathematics, Language and Culture from 1996 to 2010), in measurement questionnaires and interviews, and during village visits with data being collected by video-recording or written down by villagers. Owens and Kaleva's data as well as Lean's databases informs the discussions of this book but Lean's thesis forms the basis of Chapters 3-10. Additional data are now available from SIL and other linguistic sources and some are considered in this book where appropriate and it is possible to link to Lean's data. Chapters 11-12 by Paraide are examples of data that further inform our understanding building on Lean's initial study. However, there are likely to be discrepancies between recently recorded counting systems and the data sourced for this book as the languages of PNG since the introduction of English and Tok Pisin, money and businesses, and greater mobility and external contact have increased the changes in languages significantly. In addition, the degree of regular use of a language varies considerably along with the value placed on keeping the original form of the language.

Secondary sources. The secondary, published sources of data on PNG numerals, counting systems, or tally practices are numerous and listed in the tables collated into 17 volumes by Lean in 1992). Altogether, these sources contributed an estimated 600 or so items of data (one item of data being, for example, a set of numerals or a description of a counting or tally system for a particular language). Most but by no means all are in the reference list of this book.

In 1968, at the beginning of the data-gathering phase of this study, a search of the published literature revealed only a small number of articles which dealt specifically with aspects of numeration in PNG. The linguist S.H. Ray (1907) had included a chapter on Numeration and numerals in the Melanesian languages of British New Guinea in Volume 3 of the *Reports of the Cambridge Anthropological Expedition to Torres Straits*. The German scholar Fr. W. Schmidt (1929) included some PNG numeral data in an article on *Numeral systems* in the 1929 edition of the *Encyclopaedia Britannica*. Two SIL linguists working in the Southern Highlands Province of PNG, Karl and Joice Franklin, published an article on the *Kewa counting systems* in 1962 and subsequently in *Pacific Linguistics*, *C-53* (SIL website, Franklin & Franklin, 1962, 1978). Ted Wolfers (Wolfers, 1969, 1971), a journalist based in Port Moresby, wrote three articles on PNG counting systems, one of these appearing in the published *Encyclopaedia of Papua and New Guinea* (Wolfers, 1972). Contrary to Lancy (1978) who referred to the "scanty available literature" on PNG counting systems (and this, at the time, was probably the prevailing view of the small number of scholars with an interest in the field), Lean's exhaustive search of the ethnographic and linguistic literatures of PNG revealed a large amount of first- and early-contact data about natural language numerals and counting systems. Although the details of the sources of these data are provided in the appendices of Lean's thesis and the 1991 publications of the Provincial data, it is useful to provide a brief survey and summary here. The appendices of this book provide details of the sources for the specific languages chosen to give the background for the diverse languages and counting systems used in the argument of this book.

The earliest published examples of PNG numerals were collected by the Dutch explorers Le Maire and Schouten in 1616 during their voyage from the Netherlands to the East Indies. Brief vocabularies, including numerals, were taken at Moyse (i.e. Moses) Island and Nova Guinea; the locations of these were subsequently established, by German scholars (Schlaginhaufen, Sapper, & Freiederici, 1915–1916) to be respectively Tabar Island, situated off the east coast of New Ireland, and Muliama, situated on the south-east coast of New Ireland. More than 200 years were to elapse before further vocabularies

were collected in the New Guinea region. In 1827, the French explorer Jules Dumont d'Urville sailed through the New Guinea islands region and collected a vocabulary of the Siar language at Port Praslin near the southern tip of New Ireland, published 1883. In 1849, Owen Stanley in H.M.S. Rattlesnake sailed through the islands of the Milne Bay area and along the southern coast of Papua; several vocabularies were taken during this voyage and were published by MacGillivray (1852).

With these few exceptions, the published sources of numeral data for the coastal PNG languages begin to appear in the 1870s after the settlement of Port Moresby and the Duke of York Islands and Rabaul region. Much of the data collection for the northern part of New Guinea took place during the period of the German Protectorate, i.e. from 1884/85 to 1914, after the administrative regions of Kaiser Wilhelmsland and the Bismarck Archipelago were established. These regions encompassed what are now the Provinces of East New Britain, New Ireland, Manus, Madang, Morobe, East Sepik and Sandaun (West Sepik); most of the first- and early-contact data on the languages of these provinces emanate from the work of German missionaries and scholars during this period, the publications appearing, by and large, in books and scholarly journals rather than the official colonial reports and gazettes. Strictly speaking, Kaiser Wilhelmsland also incorporated what are now the Provinces of the vast inland Highlands region; this, however, was not penetrated until the 1930s and remained a terra incognita during the German colonial period.

The southern half of the island was called British New Guinea during the period from 1884 to 1906, and Papua from 1906 onwards. Much of the first- and early-contact data on the languages of this region derive not so much from missionaries and explorers, as is the case for German New Guinea, but from the officers of the colonial administration: the published sources of data are not so much the scholarly Zeitschrift but rather the official Government reports, notably the Annual Reports on British New Guinea (1889-1906) and the Annual Reports for Papua (from 1907). That this comprehensive collection of data exists, mainly as vocabularies which appear in the appendices of the Reports, is due largely to the efforts of two men: Sir William MacGregor, Administrator of British New Guinea from 1888 to 1898, and Dr W. M. Strong, Chief Medical Officer for Papua, both of whom had an amateur interest in linguistics and who collected data themselves as well as organising members of the colonial service to do so. Between 1889 and 1917, 389 vocabularies were published in the Reports, some others, though not so many, appearing in the period 1918 to 1940; the large majority of these contained some data on numerals. Much of this material, allowing for some differences in orthography, shows good agreement with more recently collected data. It is quite clear that some care was exercised in the elicitation and recording of vocabularies. Dating from MacGregor's time, a standard vocabulary list existed (in fact what would now be called a Standard Survey Word List) which was compiled from a set of "questions on the customs, beliefs, and languages" originally drawn up by Sir James Frazer, author of The Golden Bough. A standardised orthography was recommended, based, it seems likely, on that used by the Royal Geographical Society.

It was during MacGregor's administration that the eminent Cambridge anthropologist A. C. Haddon organised two expeditions to the Torres Strait region, the first in 1889 and the second, the famous Cambridge Anthropological Expedition to Torres Straits in 1898, in which he was accompanied by the linguist Sidney H. Ray. Ray's published works on PNG languages (e.g., 1895, 1907, 1919a), and indeed many other languages of Melanesia and Polynesia, which appeared over the period 1891 to 1938, establish him as the most important linguistic scholar of the early colonial period, rivalled only by Fr. W. Schmidt (1926, 1929). The results of the expedition were published in seven volumes, one of which is Ray's contribution on linguistics.

Excluding the vocabularies published in the Annual Reports mentioned above, something like 200 publications on linguistics and ethnographic studies of PNG appeared in the period 1875 to 1940, many of which contained data on natural language numerals and counting systems. During the 1930s, a German scholar, Dr Theodor Kluge (1938, 1939, 1941), assembled data, mostly from published sources, on the numerals of a large number of languages spoken throughout the world. Several

substantial typescripts were prepared during the period 1938 to 1941; two of these contain data on the numerals of languages of PNG and Melanesia generally. Due to the outbreak of the Second World War these materials were never put into final form and published; however the uncorrected typescripts survive and were consulted by Lean for the PNG part of this study.

Oceania

The sources of data for the six volumes on the Counting Systems of Oceania, which comprise Appendix D of Lean's study, are the published literatures of linguistics and ethnography of the geographical regions of Melanesia, Polynesia, and Micronesia. As was the case for the PNG data, there is only a small number of publications which deal specifically with numerals and counting systems. For West Papua, for example, there is a survey of counting systems by Galis (1960), together with an article by Briley (1977), an SIL member, which deals with several counting system types. For the Solomon Islands there is a study by Fox (1931) of "numerals and numeration" of the Arosi language. Macdonald (1893) had an article on the "Asiatic origin of the Oceanic numerals", although this deals in fact with a small number of Vanuatan languages. More recently, we have two further articles on numeration in the Vanuatan languages, one by Lynch (1977) on Tanna and another by Charpentier (1979) on the languages of south Malekula. For the whole of the Polynesian region, only a few studies deal specifically with numeration. Audran (1930) published a one-page summary of the numerals of several Polynesian languages. Best (1907) had some data on the counting system of New Zealand Maori and Fraser (1901, 1902) had some comparative data on the Polynesian numerals 1, 5, and 10. Heider (1926-1927) had material on the numerals and counting system of Samoan, Metraux (1936) had an article on Easter Island numerals, and Lemaître (1985) had a survey of the numerals of mainly the languages of eastern Polynesia.

As was also the case with the collection of the PNG data from published sources, particular care was taken to try to obtain as much first- and early-contact data as possible. Some of this material derives from vocabularies taken during the three expeditions under the leadership of Captain Cook in the years 1768 to 1780. Many previously unpublished vocabularies obtained during these voyages were published by Lanyon-Orgill (1979). While most of these deal with various languages of Polynesia, for example New Zealand Maori, Pa'umotu, Tahitian, Easter Island, Tongan, Marquesan, Hawai'ian, and Cook Islands Maori, there are several languages of the Melanesian region included as well which were recorded in New Caledonia and Vanuatu. During the nineteenth century much more information about the Pacific region became available as the islands were explored and settled by the Western colonial powers. Between the years 1838 to 1842, the United States Exploring Expedition under the command of Captain Charles Wilkes visited many of the islands in both Polynesia and Micronesia and the ethnographic and linguistic results of the expedition were written by Horatio Hale (1846). A memoir by Turner (1861), a missionary who had spent 19 years in parts of Polynesia, includes some comparative lexical data, including numerals, on six Polynesian languages. The German linguist Hans von der Gabelentz (1861, 1873) in his two-volume *Die melanesischen Sprachen* published a survey of a number of languages in the Solomon Islands, Vanuatu and New Caledonia. Codrington's (1885) *The Melanesian Languages* contains grammatical and lexical data on some 35 languages in the non-New Guinea Melanesian region, in particular it has a chapter devoted to numeration and numerals. A significant contributor to the study of the languages of the region was Codrington's protégé Sidney Ray. Ray published a series on the languages of the New Hebrides (Ray, 1893), on Polynesian linguistics (Ray, 1912, 1915, 1916, 1917, 1919c, 1920) and the Polynesian languages of Melanesia (Ray, 1919b). These all contain some numeral data as does his major work *A Comparative Study of the Melanesian Island Languages* (Ray, 1926).

With a few exceptions, much of the modern linguistic and ethnographic data derive from sources published after the Second World War. These will be referred to when specific languages are targeted but they are extensive and available from Lean's thesis (Lean, 1992). They will not be discussed further here but there are a few major sources of data which have been indispensable for this study and which should be noted (Christian, 1924). For example, Tryon and Hackman's (1983) *Solomon Islands Languages: An Internal Classification* has lexical data, including numerals, on all the languages spoken in the Solomon Islands. Similarly, Tryon's (1976) *New Hebrides Languages: An Internal Classification* has lexical data on all the languages of Vanuatu. Information on the languages of New Caledonia has been harder to access than the data on other languages of Melanesia, however a general survey by Leenhardt (1946), contains lexical, phonological, and grammatical data on all the languages and, for some languages, these are the only data available. For Polynesia, a series of anthropological studies published by the Bernice P. Bishop Museum in Hawaii, appeared during the period 1920 to 1950, several of these by the eminent Polynesian scholar Sir Peter Buck (Te Rangi Hiroa); some, though not all of these, contain useful data on numerals and counting (Beaglehole & Beaglehole, 1938; Buck, 1938; Christian, 1924; Handy, 1923). Finally, for Micronesia, a series of publications of the University of Hawaii Press and subsequent articles have been indispensable and have provided valuable information on Marshallese, Mokilese, Kosraean, Ponapean, and Woleaian (Bender, 1971; Harrison & Jackson, 1984; Lee, 1976; Rehg & Sohl, 1979).

It should be noted that since Lean completed his study, there have been numerous further publications of data. Goetzfridt (2008) provided brief commentary on hundreds of articles and a few specifically link to numeracy across the region. Te Māori mathematics project (Meaney, Trinick, & Fairhall, 2012; O'Sullivan, McKinley, Stewart, Richards, & Ball, 2003) in the 1990s ensured a consensus of words for counting and related concepts such as operations on numbers, groupings and so on. However, the main developments in terms of data have led at best to discussions especially in Chapters 8, 10, and 13.

The Description and Classification of Data

In order to present a coherent picture of the very large amount of number data that formed the appendices of his doctoral thesis, Lean adopted a number of descriptive terms which may be used to classify the various systems into a relatively small number of types. In some of the older linguistic literature concerned with the description of natural language numeral systems, it was common to use the descriptive term "base" when discussing the cyclic nature of the system. Thus we find counting systems variously termed "binary" (base 2), "ternary" (base 3), "quinary" (base 5), "decimal" (base 10), and "vigesimal" (base 20). Using a single number to characterise a counting system is reasonably adequate when we are dealing with, say, the English counting system which, with some irregularities, is essentially a base 10 one. The cyclic structure of many of the counting systems found in Melanesia is often more complex than the English system, in that a single system may have elements of base 2, base 5, and base 20; others have a structure in which we can discern elements of base 5, base 10, and base 20. This was recognised in the older literature in which we find reference to "mixed base" systems and such terms as "incomplete decimal" systems (that is, one which had elements of both base 5 and base 10).

As detailed in Chapter 1, pages 20–21, Lean adopted Salzmann's (1950) cycle system and the analysis of frame words and operative patterns to determine the primary and secondary cycle systems for each language.

No single typological system can do justice to the diversity and richness of the ways number words are combined to form other number words. Salzmann introduced his terms as a reaction to the oversimplistic labelling of numeral systems as found in the work of nineteenth and early twentieth century writers. Hymes (1955) criticised Salzmann's terminology as being inadequate for the description of the numeral systems of certain Native American Indian (First Nations) languages, however the criticisms do not appear to apply to the situation regarding the systems found in PNG and Oceania. As far as the typology of numerals found in the New Guinea languages is concerned, there have been several different variants applied. Ray (1907, pp. 463-478), in his discussion of numeration and numerals in the Melanesian languages of British New Guinea used the terms, as given above, for describing the "base" of the numeral system, that is "incomplete decimal", "decimal", "vigesimal", and so on. Galis (1960), in his study of the counting systems of West Papua, arrived at a sixfold classification: (1) body-part tally systems, (2) base 2 (or "binary") systems, (3) base 6 systems, (4) base 4 systems, (5) the "digit-tally" system (with a (5, 20) cyclic pattern), (6) the "Austronesian" type, i.e a base 10 system with 10 discrete numerals. Lancy (1978, pp. 6-8), introduced a four-type classification ranging from body-part tally systems (Type I); systems which have 3 to 4 discrete number words and a base of 2, 3, 4, or 5, and where objects may be used in carrying out tallies (Type II); the "quinary- vigesimal" system, that is a counting system having a (5, 20) cyclic pattern and which usually employs fingers and toes as an aid to tallying (Type III); and the "decimal" system, i.e a 10-cycle system which normally has no reference to body-parts and which has 6 to 10 discrete numerals (Type IV). Type II was based on the use of sticks or stones for tallying. However, this system often overlaps any of the other systems as mere representations. Smith (1984), in his study of the counting systems of the Morobe Province of PNG, distinguishes eight varieties of "counting procedure": (1) body-part tally systems, (2) systems with only two numerals, (3) systems which employ two numerals plus finger-and-toe "digit tally", (4) systems with three numerals only, (5) systems which employ three numerals plus "digit tally", (6) systems which employ four numerals plus "digit tally", (7) systems which have a numeral for 10, and (8) systems which have numerals for 10 and 20. In Chapter 3, 2-cycle systems includes Smith's categories 2, 3, 4, 5, and 6 (see Figure 3.1) but some of the digit tally systems are discussed in Chapter 5 if there was not a 2-cycle. In particular, it should be noted that the Salzmann system is more flexible than most of the above, particularly Lancy's system, and that discussing the systems in terms of base can be misleading as most of the systems do not follow a system of powers as in the base 10 Hindu-Arabic system. Furthermore, the use of Salzmann's terminologies assists in recognising some of the culturally related contexts, some of which were detailed by Lean but subsequent research has extended especially in Chapters 8 and 11.

Spatial Analysis of the Languages of Papua New Guinea

To illustrate the density of languages in PNG, small maps from the SIL Ethnologue have been used in Figure 2.1 to provide a spatial representation of density with names of languages or numbers (matching names in the tables on each map). It provides an appreciation of the density of the 850 PNG languages and thus the enormity of Lean's data collection and analysis.

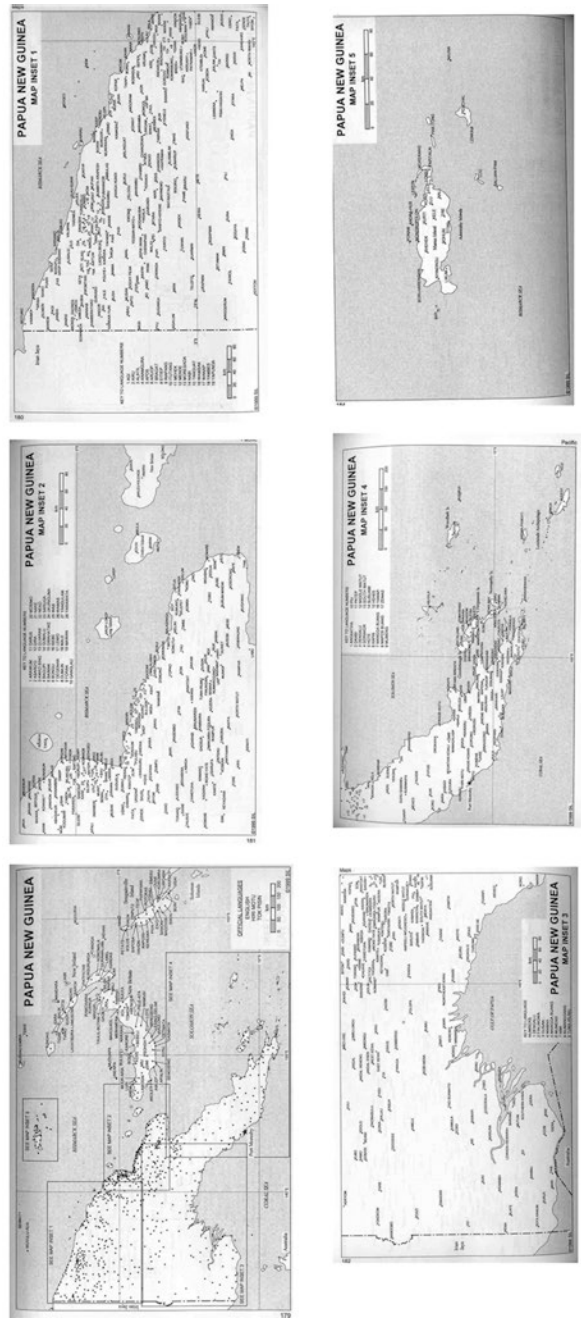

Figure 2.1. Spatial analysis of the languages of PNG.
Source. Maps from Ethnologue of languages in PNG. *Source.* (SIL, n.d.).

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