Extending the Limits of Counting in Oceania: Adapting Tools for Numerical Cognition to Cultural Needs

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Abstract

Short or object-specific counting sequences in a language are generally regarded as early steps in the evolution from pre-mathematical conceptions to greater abstraction and often as cognitively deficient. This paper scrutinizes the main numeration principles in some of the occasionally referenced instances from Melanesia and Polynesia to show that neither assumption holds categorically. The analysis of their cognitive properties, linguistic origins, and cultural context reveals that both the short and the object-specific counting sequences in Oceania did not *precede*, but were *developed* out of an extensive and abstract sequence. Furthermore, the object-specific sequences can be shown to have served as cognitively efficient tools for calculating without notation.

Key words: Numerical Cognition; Culture; Language; Evolution; Object-Specific Counting Systems

Introduction

Numerical cognition is based on two systems: an ability to roughly estimate numbers (analog numeracy) shared by various species and an ability to exactly assess a certain amount (digital numeracy), which is restricted to language and thus to humans (Feigenson, Dehaene & Spelke, 2004). Other than the system for analog numeracy, the one for digital numeracy offers a great opportunity to study interactions between culture and cognition. Its most basic cultural tool, the numeration system, is constituted by the number words developed in a language (Dehaene, 1997; Wiese, 2003, 2007). Although all numeration systems refer to the same entities, namely a certain section of integers, each of them does so in an idiosyncratic way: The highest number that can be composed regularly defines the extent of the system, cyclical patterns of number word composition define its structure or dimensionality[1], specific number words (such as «eleven» or «twelve») its regularity, and so on. Given such differences, the question arises of whether and how these culture-specific properties of numeration systems affect the way in which numbers are processed. A second question is related to this: Which of these properties are triggered by the requirements of counting and calculating in a particular cultural context?

While the former question has been extensively addressed by cognitive science, the latter has not met similar attention in this field, but has been largely restricted to evolutionary approaches. Studies addressing the first question revealed, for instance, differences in efficiency both for notational (Nickerson, 1988; Zhang & Norman, 1995) and for purely linguistic numeration systems (Fuson & Kwon, 1991; Miller et al., 1995; Pica et al., 2004). It should be noted, however, that the assessment of whether a feature is efficient always depends on the nature of the task and on the context of usage, and that the efficiency of a specific numeration system does not disclose anything about the general cognitive abilities of its users. It would therefore be rash to draw conclusions from specific properties of a numeration system to its evolutionary status. Yet, this is exactly what happens in evolutionary approaches. In their attempt to answer the second of the above questions regarding the emergence of specific properties, they conclude that numeration systems are typically developed from being simpler to more sophisticated in order to improve their efficiency on an absolute scale (Ifrah, 1985; Klix, 1993; Menninger, 1969; Nickerson, 1988).

But can one really assume that the simpler a numeration system, the older it is? The discovery of the largely restricted numeration system of the Amazonian Pirahã, which consists of just two numerals (Everett, 2005; Gordon, 2004), not only contributed to the discussion of how numerical cognition depends on language, but also revived the question of its evolution—both inside of academia (cf. discussion section in Everett, 2005) and outside. A particularly strong position is held by Premack and Premack (2005), who suppose that a genuine digital number representation did not start before the transition from hunter-gatherer cultures to cultures based on agriculture, pastoralism, and trade. However, this position not only does not do justice to the instances it refers to, but also over-generalizes to all cultures of a certain type defined in economic terms (e.g., Harris, 1987). We suppose, instead, that examining cases like the Pirahã in isolation can only yield information about how the cognitive representation of numbers interacts with the cognitive processing of numbers. However, if conclusions on the evolution of numerical cognition in general and of numeration systems in particular are to be drawn, focusing on single cases is insufficient. A coherent picture of their cognitive and evolutionary status can be obtained only when both diachronic and synchronic data are taken into account.

With instances from Melanesian and Polynesian languages in which apparently «primitive» and «advanced» systems co-occurred, the present paper will highlight the cognitive efficiency of some of the allegedly primitive properties. In demonstrating that numeration systems do not necessarily evolve in one direction only, it will also try to sensitize for the methodological risks of focusing on single cases.

[1] Zhang and Norman (1995) distinguish three types of dimensionality: In 1D systems, numbers are ordered linearly; 1x1D systems are recursive and typically operate, for instance, with base and power; and (1x1)x1D systems combine sub-base, sub-power and main power, as was the case with the Roman numerals.

Characteristics of «Primitive» Numeration Systems

In evolutionary approaches, two properties are commonly taken as indices for the simplicity of a numeration system: One is its extent, the other is its degree of abstractness. The two are largely independent of each other, both on theoretical grounds as well as in practice, and they differ in terms of the attention they have attracted: While the extent of numeration systems has been extensively addressed recently (Everett, 2005; Gordon, 2004; Pica et al., 2004), the degree of abstractness has largely been neglected so far. We will illustrate these properties with two instances for each, before analyzing the second feature in detail. All instances are drawn from the same linguistic cluster, namely the Oceanic subgroup of the Austronesian language family (Figure 1).

One region where systems with limited extent abound is Papua New Guinea. Takia, a language in Madang Province, contains five numerals (cf. Table 1). Higher number words may be composed by adding or multiplying numerals to the numeral for 5, but this seems to have been done rarely and for low numbers only (Tryon, 1995). Adzera, spoken in the Markham River valley in Morobe Province, contains an even more restricted system. Its number words are composed of numerals for 1 and 2 only: *bits* (1), *iruˀ* (2), *iruˀ da bits* (2+1), *iruˀ da iruˀ* (2+2), and so on. Due to its recursive character, counting further with this system is in principle possible: by simply adding more entities (i.e., *bits* and/or *iruˀ*) to the number word already reached. However, with only these two numerals available for tallying amounts, it will soon become difficult to keep track of the amount of addends accumulated. When in need for higher number words nowadays, people therefore prefer to use loan words from Tok Pisin instead (Holzknecht, 1986), the creole *lingua franca* used in New Guinea.

These two numeration systems are admittedly not as simple as the case of the Pirahã system, but their low bases and the lack of higher powers of their base restrict both of them. And although numerical cognition among these two Melanesian groups has not been studied experimentally, it can be inferred by analogy that, with such restricted systems, precise numerical operations should be laborious, if not impossible, for larger numbers (e.g., Gordon, 2004; Pica et al., 2004; Wassmann & Dasen, 1994).

The second property that is readily taken as evidence for restricted efficiency of a numeration system is its object-specificity. Distinguishing between «abstract» and «concrete» number sequences, Menninger (1969) assumed that numeration systems are the more antiquated the more concrete or object-specific counting sequences are contained in a language[2]. Despite its age, his works remain influential up to the present day (e.g., Klix, 1993; Wiese, 2007), and particularly the degree of abstractness in a numeration system is taken as a measure for its efficiency (Nickerson, 1988).

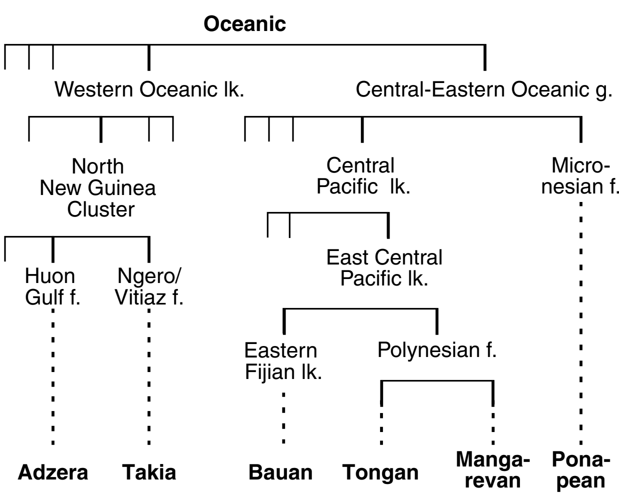

Figure 1: Linguistic origins and relationship of the languages analyzed in this paper according to Lynch, Ross & Crowley (2002); abbrev.: f = family, g = grouping, lk = linkage

Table 1: Traditional numerals for single numbers (n) and for the powers of the base (P) in abstract counting in Adzera (ADZ), Takia (TAK), Bauan (BAU), Tongan (TON), Mangarevan (MAN), and the general category in Ponapean (PNP)[a]

	Nº	ADZ	TAK	BAU	TON	MAN	PNP
n	1	bits	kaik / kisaek	dua	taha	tahi	eh-
	2	iruˀ	(u)raru	rua	ua	rua	ria-
	3		utol	tolu	tolu	toru	silu-
	4		iwaiwo	vā	fā	hā	pahie-
	5		kafe-n	lima	nima	rima	lima-
	6			ono	ono	ono	wene-
	7			vitu	fitu	hitu	isu-
	8			walu	valu	varu	walu-
	9			ciwa	hiva	iva	duwa-
P	10^1			tini	hongofulu	rogo'uru takau	-ngoul
	10^2			drau	teau	rau	-pwiki
	10^3			udolu	afe	mano	kid
	10^4				mano	makiu	nen
	10^5				kilu	makiukiu	lopw
	10^6					makore	rar
	10^7					makorekore	dep
	10^8					tini	sapw
	10^9					maeaea	lik

[a] **Sources:** Bender & Beller (2006a, 2006b), Churchward (1941), Holzknecht (1986), and Tryon (1995)
Please note that in Mangarevan, from *takau* onwards, the numerals refer to $2 \cdot 10^x$ (shaded).

[2] Such concrete or object-specific counting sequences are linked to numeral classifier systems—a point to be picked up below. With a growing body of research on numeral classifiers (e.g., Aikhenvald, 2003; Craig, 1986), most of Menninger's assumptions have been given up meanwhile, but the status of the object-specific counting sequences has been largely neglected.

Table 2: Specific counting systems in Tongan[a]

		2	4	…	20	40	…	200	400	…	2,000	4,000	…
group 1	sugar-cane	taha (**ng.**)	ua (ng.)	…	te-**tula**	ua[ngo]tula	…	te-au	ua[nge]au	…	taha afe	ua afe	…
	coconuts	taha	ua	…	te-**kau**	ua[nga]kau	…	te-**fua**	ua-fua	…	te-au	ua[nge]au	…
group 2	yam	taha	ua	…	te-**kau**	ua[nga]kau	…	te-**fuhi**	ua[ngo]fuhi	…	te-au	ua[nge]au	…
	fish	taha	ua	…	taha (**kau**)	ua (kau)	…	ho[ngo]fulu	uo-fulu	…	te-au	ua[nge]au	…

[a] Specific numerals are highlighted bold-faced at their first occurrence; the principal counting units (*ng.* = *nga'ahoa* in group 1 and *kau* in group 2) are shaded. The ligature appearing in the lower ranges (*-nga-/-nge-/-ngo-*) is put in square brackets for easier comparison.

One of the languages referenced by Klix (1993, p. 283f.) as having such object-specific counting sequences is Bauan (Old High Fijian), a language in the Eastern part of Fiji: While it glosses 10 as *bola* when fish are counted, for canoes, *udundu* is used. In connection with canoes, *bola* denotes 100 (Churchward, 1941). Similar object-specific counting sequences can be found in the related Polynesian and Micronesian languages. On Mangareva, for instance, a volcanic island group in French Polynesia, tools, sugar-cane, pandanus, breadfruit, and octopus were counted with different sequences (this case and the related Tongan instance will be analyzed in more detail below).

From an evolutionary point of view, it may appear reasonable to regard such specific counting systems as predecessors of an abstract mathematical comprehension and accordingly as cognitively deficient. But surprisingly, these same systems often also contained numerals for large powers—as far as 10^9 in Mangarevan—thus defining an extent not compatible with the conception of «primitive» numeration systems. Even more important, the languages depicted here had inherited a regular and abstract decimal numeration system with (at least) two powers of base 10 from their common ancestor, Proto-Oceanic (Lynch, Ross & Crowley, 2002; Tryon, 1995). Both the relative limitation of the two numeration systems in Papua New Guinea and the specific counting sequences in Fiji and Polynesia therefore constitute subsequent developments. While the former might count as a case of regression in evolutionist terminology, the latter are more complex and therefore require an elaborate analysis.

Numeration Principles

In order to demonstrate the efficiency of the allegedly primitive specific counting systems, two Polynesian instances will be analyzed below: Tongan, which contains one of the most 'regular' specific systems, and Mangarevan containing one of the most complex systems. To illustrate the composition, reference will also be made to the numeral classifier systems found in related Micronesian languages (such as Ponapean).

Numeration Systems in Tongan

Traditional Tongan contained an abstract numeration system (Table 1) and four additional counting sequences for specific objects (for a more detailed description see Bender & Beller, 2007). Any number word in the abstract sequence (N_{ab}) is composed according to the following polynomial (ligatures are omitted for the sake of clarity)[3]:

[1] $N_{ab} = [n\ P_{10^5}] + \ldots + [n\ P_{10^2}] + [n\ P_{10^1}] + [n]$

with $n \in \{1, \ldots, 9\}$ and P = power numeral (according to Table 1)

The specific counting sequences are depicted in Table 2. As can be seen, each of these sequences proceeded with partly diverging numerals (such as *-tula*, highlighted bold-faced in Table 2) and in diverging steps. Old reference grammars therefore treat each sequence distinctly. However, if we order them not by the amount of single items but by the principal counting units (shaded in Table 2), the differences between the sequences collapse, revealing a polynomial for number words in the specific sequences (N_{sp}) quite similar to the one used in abstract counting:

[2] $N_{sp} = [n\ P_{10^5}] + \ldots + [n\ P_{10^2}] + [n\ C_{10}] + [n][C_1] + [\text{Rest}]$

with $n \in \{1, \ldots, 9\}$, P = power numeral analogous to the abstract sequence (cf. Table 1), $C_{10} \in$ {*-tula*, *-fua*, *-fuhi*}, and $C_1 \in$ {*nga'ahoa*, *-kau*}
(the Rest consists of 1 single item (*matelau*) in group 1, and of *n* pairs and/or 1 single item in group 2)

What distinguishes the specific sequences from the general one are the counting units to which they refer (pair or score) and the numerals for ten of these (i.e., *-tula, -fua*, and *-fuhi*).

Numeration Systems in Mangarevan

Besides an abstract numeration system that, from 20 onwards, proceeded in pairs with $P = 2\cdot10^x$ (cf. Table 1), traditional Mangarevan also contained three specific counting sequences for certain objects (for more details see Beller & Bender, 2008). Any number word in the abstract sequence (N_{ab}) is composed according to the following polynomial:

[3] $N_{ab} = [n\ P_{2\cdot10^9}] + \ldots + [n\ P_{2\cdot10^1}] + [P_{10^1}] + [n]$

with $n \in \{1, \ldots, 9\}$ and P = power numeral (according to Table 1)

The specific sequences are depicted in Table 3. Each of them proceeded in diverging steps, some of which were no longer decimal, and contained power numerals different from the abstract power numerals. However, this apparent divergence again disappears if we order them not by the amount of single items but by the principal counting units (shaded in Table

[3] For instance, 241 is denoted as "ua[nge]au fā[ngo]fulu mā taha" (with the ligature *-nge-/-ngo-* in square brackets for easier comparison, *mā* = "and", *-au* = $P_{2\cdot10^1}$, and *-fulu* = $P_{2\cdot10^1}$).

Table 3: Specific counting systems in Mangarevan[a]

	2	4	6	8	…	20	40	80	160	320	640	…
Category 1	**tauga**	rua tauga	toru tauga	hā tauga	…	**paua**	**tataua**	**varu**	rua varu	hā varu	varu varu	…
Category 2	—	**tauga**	—	rua tauga	…	rima tauga	**paua**	**tataua**	**varu**	rua varu	hā varu	…
Category 3	—	—	—	**tauga**	…	—	rima tauga	**paua**	**tataua**	**varu**	rua varu	…

[a] Specific numerals are highlighted bold-faced at their first occurrence; the principal counting units (*tauga* and *varu*) are shaded.

3). The three sequences then collapse into a single syntactic rule, according to which any number word in any of the three specific sequences (N_{sp}) is composed:

[4] $N_{sp} = \ldots + [n\, P_{40}] + [P_{20}] + [P_{10}] + [n \cdot P_1] + [\text{Rest}]$

with $n \in \{1, \ldots, 9\}$, P_{40} = *varu*, P_{20} = *tataua*, P_{10} = *paua*, P_1 = *tauga*, and Rest = n · *tou'ara*

Depending on the category of objects counted, the principal counting unit *tauga* contained itself either two, four, or eight items. The binary steps in the specific sequences (i.e., *paua* and *tataua*) are difficult to explain—except if we regard *varu* as their principal counting unit, as indicated by cultural preferences. In this case, *paua* and *tataua* would have served as short cuts that facilitated the representation of the incomplete units. The specific sequence would then be a «modulo 40 system» in which units of 40 *tauga* were counted, and the remainder (if any occurred at all) was decomposed in 20 + 10 + n.[4] In other words: Although—at first glance—the specific counting systems in Mangarevan may appear much more irregular than those in Tongan, they still follow a remarkably regular pattern.

Specific counting sequences like these were adopted in nearly every language in Polynesia and even beyond, and they all operated with counting units other than 1 (Bender & Beller, 2006a, 2006b). With only a few (questionable) exceptions such as Mangarevan, the specific sequences regularly accompanied a general sequence that was purely decimal and abstract[5]. As this general sequence is constructed according to simple and coherent rules, it fulfils all of the requirements of a well-designed and efficient numeration system. Why, then, the object-specific counting sequences?

Cognitive Properties of Specific Counting Systems

The main effect of the specific counting sequences was to abbreviate numbers by extracting from the absolute amount the factor inherent in the counting unit. This extraction has implications for critical factors for mental arithmetic. It directly affects the problem size effect in that it reduces calculation time (Dehaene, 1992), and it indirectly affects base size, which is associated with a cognitive trade-off (Zhang & Norman, 1995): While large bases are more efficient for encoding large numbers and may, by virtue of compact internal representations, facilitate mental operations, they also require the memorization of larger addition and multiplication tables for calculations. Small bases, on the other hand, are cumbersome for the representation of large numbers, but advantageous when it comes to simple calculations. This holds particularly for the binary system, as is well known since the work of Leibniz.

In many Polynesian languages, a preoccupation with 2 is apparent (Bender & Beller, 2006a), and this is particularly true for Mangarevan. Not only do its three specific sequences differ with regard to the value of their counting unit *tauga* by factor 2, but their general decimal pattern is also modulated with elements of a binary system. In Tongan, the pair as counting unit was also prevalent in the lower ranges, but was reinforced by factor 10 (yielding the score as counting unit) in the higher ranges.

Overall, these specific sequences entailed a range of facilitation effects. One of these effects was that counting specific objects was enhanced by counting them in larger units: in pairs, quadruples, or eights as in Mangarevan, or in scores as in Tongan. In addition, extracting the respective factor abbreviated higher numbers. Introducing a larger counting unit therefore compensates the cognitive trade-off associated with base size. It combines advantages of large and small base sizes insofar as it facilitates encoding, internal representation, and memorizing of larger numbers (in terms of absolute amounts), and at the same time keeps base size comfortably small for mental arithmetic. Encoding, for instance, 48 ripe breadfruits in Mangarevan as 12 units = 1 *paua* + 2 *tauga* produces compact number representations as in a base 40 system; at the same time, calculating ensued with the addition and multiplication tables of the decimal base, supported by two binary steps. Or, to illustrate the principle with a more familiar instance, consider how much easier it is to mentally calculate *6 dozens – 3 dozens + 2 dozens* than to calculate *72 – 36 + 24*.

Although the analysis of their cognitive properties clarifies the efficiency of specific counting systems, their evolutionary status still remains unresolved. Did they precede the abstract systems, as is assumed by evolutionary accounts, or could it also have been the other way around? And if they were derived from the abstract ones, was this done deliberately, or did it just happen by accidental linguistic change?

[4] This may not be the most efficient method of decomposition, but—given the generally decimal nature of the system—it was surely the most preferable. The next possible decomposition (20 + 10 + 5 + n) would have arbitrarily restricted the single numerals to $n \in \{1, 2, 3, 4\}$.

[5] The switch from 10 to 20 in the general sequence in Mangarevan is atypical in this regard. However, as many of the traditional numeration systems were replaced in colonial times before they were documented, information on a regular system may simply have been lost.

Linguistic Origins and Cultural Adaptations

We propose that the specific counting sequences were *derived* from the abstract one, and that this was done *on purpose*. Although it is impossible to provide unquestionable evidence for this hypothesis due to the lack of written sources, both linguistic and cultural arguments can be mustered to support this proposition.

The first argument concerns the linguistic origin of the specific counting sequences. While in almost all Polynesian and Micronesian languages, specific counting systems co-occurred with abstract ones, the homogeneity among the abstract ones is much greater than among the specific ones. The only features the latter have in common are their object-specificity (they apply to certain objects only) and the multiplication function (they are based on counting units larger than 1). Apart from that they diverged considerably—even among closely related languages—in terms of the precise value of the counting units (ranging multifariously from 2 in the most simple to 20 in the most extensive case), the objects of reference (depending on ecological availability and cultural salience), and the specific lexemes used to identify distinct sequences (Bender & Beller, 2006a, 2006b). Taken together, these idiosyncratic details in a basically similar composition pattern indicate that each culture had inherited the same abstract system, from which the specific systems were derived individually and in response to cultural needs.

This inference is further corroborated by the constitutive role that numeral classifiers play in the composition of counting sequences (already hinted at in Footnote 2). Nearly all specific counting systems in Polynesian languages are based on the original abstract counting sequence modified by specific terms for the first power of the base. Whereas in Tongan, for instance, the term for 100 units is uniformly *teau*, 10 ordinary things are glossed as *hongofulu*, 10 units of sugar-cane as *tetula*, and 10 units of coconuts and yam as *tefua* and *tefuhi*, respectively (cf. Table 2). These specific lexemes, semantically referring to the object counted, are residuals of numeral classifiers and link the Polynesian systems to the classifier systems prevailing in Micronesian languages. Numeral classifiers are obligatory components of counting constructions in many languages (Aikhenvald, 2003; Craig, 1986) and group the associated nouns into classes according to some sort of salient characteristics. A close counterpart in English are words like *sheet* in «two sheets of paper». The most relevant point here is that they in themselves constitute specific counting systems, as they affect the way in which each object is to be counted (e.g., paper in «sheets», cattle in «heads», etc.). But unlike the numeral classifiers in the Micronesian languages, those used in Polynesian numeration systems did not just classify nouns, but also always implied a counting unit different from one (for more details see Bender & Beller, 2006b), which indicates a deliberate extension.

The third supportive point is provided by the cultural context of counting in Polynesia. One of the remarkable facts about numeration systems in Polynesian languages is their large extent. Distinct power terms reach as far as 10^5 (*kilu*) in Tongan or even 10^9 (*maeaea*) in Mangarevan. Across Polynesian cultures, both the extent of the number systems and the number of counting sequences tend to increase with increased stratification. In the highly stratified societies, certain resources were regularly allocated and redistributed by powerful chiefs or kings (Bellwood, 1987; Kirch, 1984). In pre-colonial times, Mangareva was one of these stratified societies and a junction for the long-distance exchange of goods. Accordingly, tributes and large shares for trade were regularly due. The same holds for Tonga that from 950 AD onwards was reigned by a powerful monarchy and where, at certain occasions such as wars or funerals or when allocating and redistributing tributes, certain objects were necessitated in large amounts (Bender & Beller, 2006a, 2007). In these cases, calculation rather than counting was required, and when ceremonial purposes or prestige were involved, this had to be done very carefully. Keeping track of the flow of goods and coordinating their redistribution was an important task, and without notation (and particularly so when large numbers were involved), it was a difficult task. In this context, specific counting sequences with their abbreviation function served practical reasons.

The interpretation that the specific counting sequences were designed to facilitate mental arithmetic is further supported by indications that, during the early stage of colonialism, a range of Polynesian (and Micronesian) cultures began to develop notational systems. Hawaiian tax gatherers, for instance, seem to have used quipu-like knots for their records (Barthel, 1971). Although none of these instances can clearly be traced back to pre-colonial times, they hint at a genuine need for facilitating the accounting process.

To sum up, our analysis reveals that the specific counting systems in Mangarevan, Tongan, and other Polynesian languages did not precede an abstract system, but were rather derived from it. Most likely, this was done deliberately and for rational purposes. Regarding these systems as primitive or cognitively deficient is therefore, despite their non-abstract nature, not justified.

Conclusion

There is no doubt that numeration systems differ with regard to how efficient tools for cognitive arithmetic they are, and classifying them along this dimension is a useful endeavor. We do not challenge, either, that numeration systems change over time. On the contrary, the numeration systems in Oceania provide ample evidence of this fact. But we do challenge that picking instances from 'exotic' cultures and lining them up in one evolutionist order adequately describes the underlying process.

Not all cultures value numbers in the same way, even if they may be concerned with mathematical topics (Ascher, 1998). In some cultures in Melanesia, for instance, large power numerals were given up together with decimal systems and replaced by quinary or body-counting sequences (actually, this happened in roughly 15 % of the 80 languages documented in the Comparative Austronesian Dictionary; Tryon, 1995, IV, p. 50-52). In other cultures, the reverse of this took place: Not satisfied with the restrictions posed by their inherited numeration system, many Polynesian and Micronesian cultures not only extended its limits of counting, but also designed efficient strategies to cope with the cognitive difficulties of mental arithmetic.

Both lines of development started from the same regularly decimal and abstract numeration system inherited from Proto-Oceanic and therefore speak against the assumption of a linear evolution of numerical cognition (cf., Premack & Premack, 2005). In other words: Numeration systems do not always evolve from simple to more complex systems.

In addition, as the case of the Polynesian languages demonstrates, they do not always evolve from concrete or object-specific to abstract systems either. Like their Micronesian relatives, many Polynesian languages systematically incorporated numeral classifiers into an originally abstract system in order to obtain larger counting units that facilitated the processing of larger numbers in the absence of a notation system. Despite their non-abstract nature, the specific counting systems constituted innovative ways of counting and therefore cannot count as primitives. Taken together, these two arguments should caution researchers against considering contemporary numeration systems in Oceania—as well as anywhere else in the world—as testifying different steps in mathematical comprehension.

There may be no other domain in the field of cognitive sciences where it is so obvious that language (i.e., the verbal numeration system) interacts with cognition (i.e., mental arithmetic). One of the two «core systems of number» hinges on language (Feigenson, Dehaene & Spelke, 2004; Wiese, 2007). Cases like those presented here therefore also illustrate—if thoroughly examined—how creative people are in adapting their cognitive and linguistic tools to cultural needs.

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