

## Language and the emergence of recursivity in the numerical domain

Heike Wiese, Humboldt-Universität Berlin (heike.wiese@rz.hu-berlin.de)

It has often been noted that recursivity and, based on recursivity, discrete infinity can be found both in the linguistic and the numerical domain. This has led to the assumption that this feature has been transferred from language to number (e.g. Chomsky 1988). However, as Bloom (1994) pointed out, recursivity is a holistic property of systems that cannot be passed on from one system to the other: it is a feature that does not emerge out of single rules, but rather out of their interaction.

Hence we are left with the puzzle of how recursivity could have evolved in numerical thinking in the first place. If we do not want to assume that it evolved twice and totally independently in each domain, how then could this principle have been transferred? What could have been the vehicle that made it possible for recursivity to pass the gap between language and numerical cognition?

In my talk I show that it is counting words, the sequences of words used in counting, that provide the crucial bridge from the linguistic to the numerical domain: I am going to argue that *recursivity travelled on counting words*. My argument takes four steps:

1. I show that there are three basic kinds of number contexts: cardinal, ordinal, and nominal contexts. In these contexts, numbers identify the cardinality of sets ('three buses'), the ranks ('the third bus'), or the identity of empirical objects ('bus #3'), respectively. I demonstrate that in order to be used in these different contexts, numbers must (i) be well-distinguished, and (ii) be ordered in a progression.
2. I show that, unlike object labels, counting sequences of natural languages satisfy these conditions. This means that they can be characterised as *numerical tools*: they are exceptional words that have an instrumental, rather than referential, status in number assignments.
3. I describe a possible scenario for the emergence of such tools, suggesting that in a process of co-evolution the gradual emergence of counting sequences and the development of a more and more comprehensive number concept supported each other. This scenario is based on the following main stages:
  - First, a series of words is used to indicate different cardinalities iconically ('one, and another one, and another one' etc.). Evidence for such systems can be found for instance in some early Australian cultures (cf. Strehlow 1945 on Aranda; Dixon 1980).
  - Later, different words are employed for individual elements of this series in a stable order, probably connected to finger counting. Evidence for such a connection comes from body counting systems (cf. Saxe 1981, 2003 on Oksapmin), but also from the frequent occurrence of base-ten structures in counting sequences, and from diachronic links of counting words to fingers or the act of bending fingers (e.g. Winter 1992 on Proto-Indo-European; Petitot 1876 and Menninger 1958 on Dëne Sųłiné).
  - Finally, different positions in this sequence are used to indicate different cardinalities. This usage can then be generalised and transferred to other, non-quantitative number contexts.

At this point, we have a sequence of words that fulfills both of our conditions on numerical tools, and is used in different kinds of number assignments. In order to do so, this sequence does not need to have the property of discrete infiniteness yet: discrete infiniteness is an optional, additional feature that makes sure that there are no limitations to the size of the empirical sets that numbers can be assigned to, but it is not indispensable for a number sequence. However, given that our numerical tools are *words*, they provide the option to employ recursion and thereby implement discrete infiniteness into the system:

4. I argue that since the numerical sequence described in this scenario is a sequence of words, (a) we can add arbitrary new elements as long as they are in keeping with the morpho-phonological restrictions of the language, and (b) these new elements can be created according to grammatical rules, which means that we can generate infinitely many of them (based on a small set of primitive items) *by employing the recursive rules the linguistic system provides*.

According to this account, recursivity could be passed on from language to number because it did not have to be transferred as an isolated feature: in order to use, in the numerical domain, the recursivity that language provides one does not have to move out of the system in the first place, but can use linguistic recursivity right away, the recursivity that counting words bring with them as lexical items.

Note that this implies that via counting words – used as numerical tools – language *supports* the implementation of recursivity and hence infiniteness in the numerical domain, but it does not necessarily trigger it. This explains why not all cultures have an infinite, recursive number system, although once the need arises they can develop one, or implement one from another culture when they get into contact with it.