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From Core Knowledge Representations to Linguistic Numbers : An Universal Base for Counting

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1. ANS and OTS in Mundurucu

Mundurucu use of numbers exhibit psychophysics properties of both the ANS (**Approximate Number System**), Pica et al., 2004) and OTS (the **Object-Tracking System**), Pica et al., 2008).

Spoken or written Mundurucu number words can only refer to approximate quantities, with an uncertainty that increases with number (Weber's law), see Figure 1.

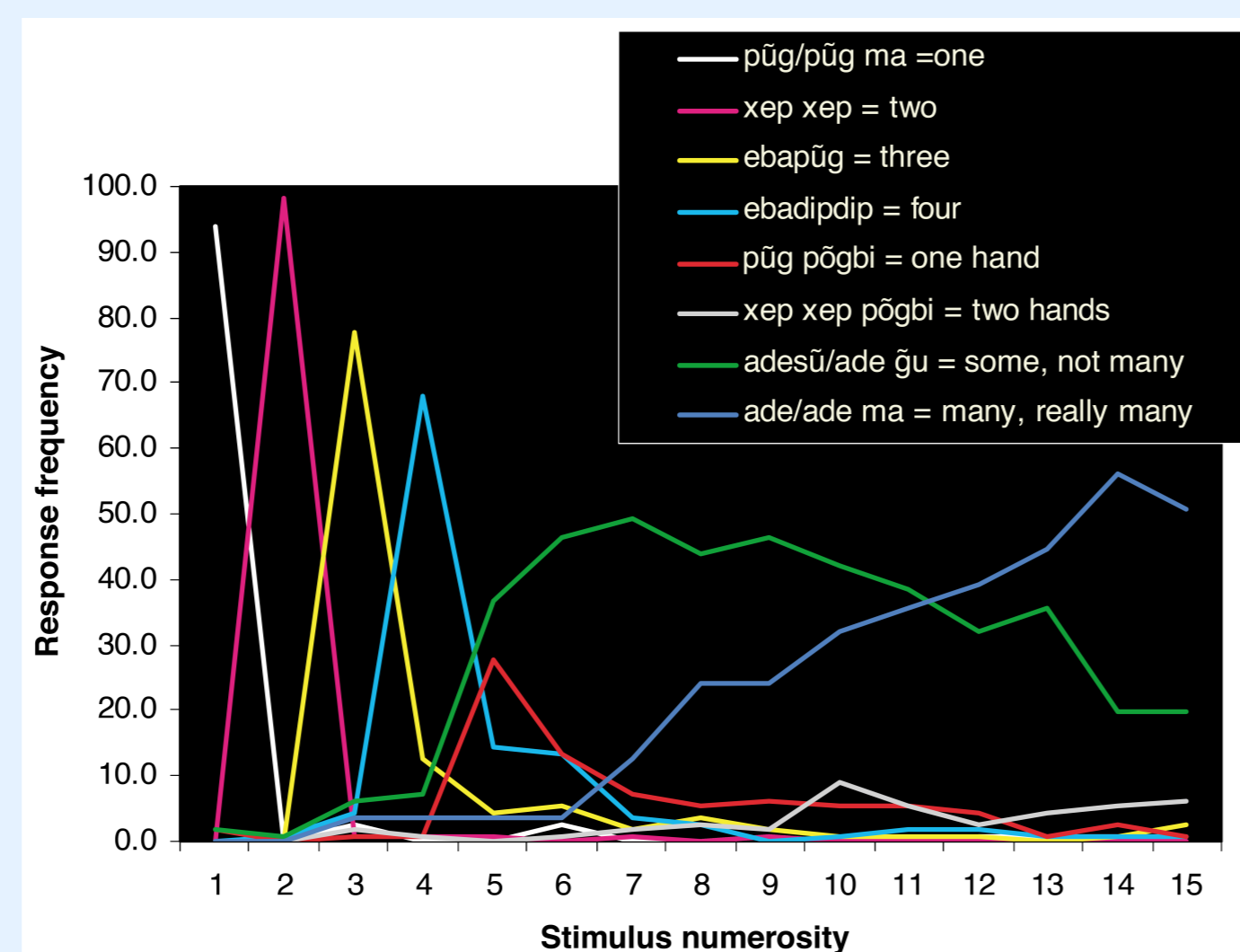


Figure 2, Give-a-Number task (after Wynn, 1990)



Age < 3 1/2 «Subset Knower»
Can produce sets from numbers up to 1,2 or 3.

« Give me three seeds! »
Stimuli: pûg ,xep xep, ebapûg, ebadipdip, pûg pûgbi, etc (from Izard et al., 2008)

How to reconcile the exact number of syllables (OTS) and the Weber's law effect (ANS) data in Mundurucu?

3. Chunks and base

Crucially, chunks of more than two individuals are not observed. Moreover, any chunk is made of individuals of the same kind of objects (Feigenson, 2008). This constraint on homogeneity applies to additive structures as well.



Figure 3, xepxep pûgbi

It follows from these observations that counting in Mundurucu is «object-specific». It is now possible to analyze 'pûgbi' (lit *hand*) in 'pûg pûgbi' (lit *one hand(ful)*, or 5) **not** as a *chunk*, but as an *approximate base*. See also 'xepxep pûgbi' (lit *two hands* or 10).

2. Linguistic structure of Mundurucu numerals

Mundurucu number words are long, often having as many syllables as the corresponding quantity, see Table 1. Each syllable refers to an individual, as perceived in the OTS system.

Table 1

Word	Reference	Syllables
Pûg	Between 1 and 2	One
Xepxep	Between 1 and 3	Two
Ebapûg	Between 2 and 7	Three
Ebadipdip	Between 3 and 8	Four

Number words in Mundurucu can be recursively obtained through the application of the operator "**other**". "Other" can apply to a constituent "one object" to yield a structure "(an) other object".

For example, xepxep can be analyzed as [xep [**other** xep]] (with the meaning 'one, other one').

The operator **other** is expressed through syllabic reduplication. The reduplication will be interpreted as a functional category. It follows that reduplication can be applied only to "meaningless" syllables.

It is possible to analyze a numeral such as ebadipdip as a chunk 'eba' (lit 'your two arms') followed by another chunk 'dipdip', where the first 'dip' is interpreted as 'one object' and the second 'dip' as '(an) other one object'.

Linguistic structure is an important window for the study of core knowledge systems (CK) and their relation to vision. Core Knowledge Systems are viewed as building blocks of the C/I domain. Taking as a starting point Mundurucu, a language with few numerals (up to 5), we suggest that the language faculty satisfies external constraints in a minimal way.

4. Conclusions and prospects

The structure of number words follows from the above principle and analysis; e.g. *pûgpûg. At a general level, these facts follow from the constraints on **other** and its antecedent. The analysis extends to *xepxep pûg (with the meaning 2+1) if we assume that reduplication cannot take place inside an additive structure. Ebapûg is completely natural.

The analysis developed resolves a tension: on the one hand, the number of syllables for numerals until 4 (but crucially not for 5) seems to express the exact cardinality of the numeral; on the other hand, all numerals are interpreted as approximate quantities. The fact that every tracked individual is expressed is indeed due to external constraints (OTS). These constraints, in turn, explain the approximate meaning of the numerals (ANS). Linguistic structure satisfy properties of both systems.

Interestingly, examples such as 'the three of us', 'the three of us', 'all three of us', versus * 'the seventeen of us', * 'all seventeen of us', etc. might hint that these constraints are universal.