Working memory constraints: Implications for efficient coding of messages

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This paper starts from the assumption that in an effective and economic communication system the information should be distributed as uniformly as possible over time, and the average level of information transmitted per time should be adapted to our cognitive capacity limits (Fenk & Fenk 1980). Here, I focus on the limited cognitive resource ”working memory“ and its implications for communicative efficiency. Working memory is supposed to be limited in the number of items (Miller's 1956 “magic number 7 ± 2”, or Cowan's 2001 “magical number 4 ± 1”) as well as in terms of duration, e.g., Baddeley's (1986) phonological loop model (subjects can recall as much as they can rehearse in 1.5 – 2.0 sec.).

An earlier study (Fenk-Oczlon 1983) tested the hypothesis that language has adapted to memory limitations and that the number of syllables per simple declarative sentence encoding one proposition will cross-linguistically vary within the range of Miller's magic number 7 ± 2. It shows that the 61 languages investigated so far (Fenk-Oczlon & Pilz 2021) indeed use on average 7.1 syllables to express a matched set of 22 simple declarative sentences, but the individual languages show a considerable variation in the number of syllables, ranging from 4.64 syllables in Thai up to 10.95 in Telugu. We assumed that syllable complexity might be the decisive factor for this variation and found a strong inverse relationship between clauses length in number of syllables and syllable length in number of phonemes. Concerning Cowan's magical number 4 ± 1, it reveals that languages use on average 3.7 words per clause, ranging from 2.6 in Turkish up to 5.4 in Mandarin. Moreover, a significant negative correlation was found between the number of words per clause and the number of syllables per word. Memory constraints in terms of duration (Baddeley's 1.5 - 2 sec) show in the trade-off between number of syllables per sentence and number of phonemes per syllable: a mean of 10 simple CV syllables like in Japanese or 5 complex syllables like in Thai corresponds to about 1.5 – 2 seconds.

Thus: All relevant working memory constraints discussed in the literature, show in the length of simple declarative sentences expressing one proposition (cf. Fenk-Oczlon & Fenk 2001). Moreover, time limits (Baddeley's 1.5 - 2 sec) force trade-offs between number and length of relevant units.

A time span of 1.0 – 2.0 seconds for producing a proposition is also observed in sign languages (Bellugi & Fisher 1972). As to memory limitations in number of items, Malaia and Wilbur (2019) report a lower memory span with signers (5 ± 2) than with speakers (7 ± 2). This discrepancy is often explained that signs take longer to produce than words. “the same store, bigger unit explanation” (Gozzi et al. 2011:106) is supported by our findings from spoken languages: Languages with longer words tend to have a lower number of words per memory span.

Efficient communication is achieved when language users have minimal effort to successfully send and receive messages (Gibson et al. 2019, Levshina 2022). Our data suggest that minimal effort and efficient communication is achieved when clauses, dependency distances (cf. Liu 2008, Gomez-Rodriguez et al. 2022), etc., do not exceed working memory limitations. The findings are discussed within the framework of Systemic Typology (Fenk-Oczlon & Fenk 1999) arguing, for instance, that memory constraints and the trade-offs found also influence word order in spoken and sign languages.

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