What language tells us about immediate memory span

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Abstract

Die Studie beschäftigt sich mit dem nach wie vor aktuellen Problem (z.B. Shiffrin & Nosofsky 1994, Engle et al. 1999), wie denn das Konzept oder die Konzepte eines "Kurzzeitgedächtnisses", eines "Arbeitsgedächtnisses" und eines "immediate memory" operational zu definieren seien – informational (in bits), als fixe Anzahl (von Elementen oder "chunks" aus Elementen), oder als Zeitspanne. Anstatt, wie in der kognitiven Linguistik üblich, nach dem Erklärungswert kognitionspsychologischer Konstrukte für die Linguistik zu fragen, wird nun versucht, empirische Resultate crosslinguistischer Forschung (zuletzt: Fenk-Oczlon & Fenk 1999) zur Klärung der obigen Frage heranzuziehen. Dabei zeigt sich, dass die drei in der Psychologie diskutierten "constraints" in der sprachlichen Segmentierung zusammenfallen: Sie werden manifest in der Dauer von Clauses, der pro Silbe transportierten Informationsmenge und der Anzahl von sieben plus minus zwei Silben pro Clause.

Thesis 1: The structure of natural language contains information about the structure of our cognitive apparatus.

One may view language as a product of our cognitive system or as the "Procrustean bed" of thinking; we may view it as a subsystem of the cognitive system or view the cognitive system as the most influential environmental system of language; or proceed from the perspective of a co-evolution (Deacon 1997, Fenk-Oczlon & Fenk 1996) of brain and cognition on the one hand and language on the other hand. Or assume that the evolution of the language system was subject to the constraints of our cognitive system, which would mean, that the cognitive system is the "Procrustean bed" of language evolution. Not all of these perspectives are equally plausible, and not all of them are mutually exclusive. But all of them have in common that language must convey some information about the cognitive system. Language can tell us something about this cognitive system. And it may well be that it can tell us - in some respects at least - even more about the architecture of our memory-system than the psychologists' recall- and recognition experiments with series of any sort of elements. This makes it tempting to turn the table - i.e. to draw inferences from language-structure on cognition instead of, as in former studies (Fenk-Oczlon & Fenk 1994), the other way round.

Thesis 2: Time is a more or less explicit factor in any operationalisation of the capacity of "short-term memory" and/or "working memory".

Within cognitive psychology there is an extensive discussion about possible distinctions between components of the memory system (such as the "sensory buffer" and "short-" and "long-term memory" in Atkinson & Shiffrin 1968) and possible distinctions between processors involved in short-term retention, such as "short-term memory" and "working memory". This debate is not new (c.f. Fenk-Oczlon & Fenk 1995: 226 f.) but still actual (Engle et al. 1999). The central question is of course the operationalisation of capacity limitations. Regarding such operationalisations Schweickert & Boruff (1986: 424) summarised: "...the capacity of the short-term store is not determined by a fixed number of items, bits or chunks, but by the limited time for which the verbal trace endures." But time is, for obvious reasons, also involved in operationalisations focusing on bits and on chunks, because the dimensions in question are the "information (in bits) per time" or the number of items that is grasped "at a glance" (Miller 1994:348). If there is something like a fixed number of items then it is most probably a fixed number of items that can be processed within a fixed time interval, i.e. within a phase or cycle that is characteristic for our cognitive processing.

Thesis 3: Time, bits, and chunks - all three constraints affect language segmentation.

In spoken language there are only two entities corresponding to *rhythmic* processing - the syllable as the basic element and the clause or intonation unit at a higher order level. (The unit in between these two levels is the word. It is the most widely used material in memory experiments and is of course interesting because of its semiotic status. But it is not the appropriate candidate in the search for elements and components of rhythmic organisation.) Thus, a crosslinguistic experimental study (Fenk-Oczlon 1983) was conducted in order to test the assumption that the number of syllables per clause would vary within the range of the magical number seven plus minus two. The clauses used were of a special quality: simple declarative sentences encoding one proposition in one intonation unit, such as *blood is red* or *the sun is shining*. 22 German sentences of this sort were presented to native speakers of 27 different languages. Native speakers were asked to translate the sentences into their mother tongue and to determine the length of the translated sentences in syllables. The results: The mean length was 6.43 syllables per sentence; the lower end of the distribution was marked by Dutch with a mean value of 5.05 syllables and the higher end by Japanese with 10.2 syllables.

A statistical reanalysis (Fenk-Oczlon & Fenk 1985) should clarify the question about the relevant factor determining the position of single languages on the continuum "mean number of syllables per sentence". The factor coming under suspicion was the syllable-complexity, i.e. a language's mean number of phonemes per syllable. One cause of suspicion was that the articulation of more complex syllables takes up more time. Another cause was that Dutch is known for its complex syllables and Japanese for its simple CV-syllables. The result was a highly significant negative correlation ($r = -0.77$, $p < 0.1\%$) between mean number of syllables per sentences and mean number of

phonemes per syllable. The interpretation: Languages with higher syllable complexity need, proportionate to the higher expenditure of time per syllable, fewer syllables for encoding a certain proposition. The whole set of crosslinguistic correlations found in later studies (Fenk & Fenk-Oczlon 1993, Fenk-Oczlon & Fenk 1999) with a meanwhile extended sample of languages conforms to this interpretation suggesting that all three constraints discussed in psychology - time, information, number of items - become manifest in the rhythmic organisation of language. Findings allow to bring together different lines of argumentation - even in cases where the positions in question are as yet discussed as incompatible with each other.

Regarding capacity limits of immediate memory, Miller (1956) proposes a constant number (7 plus minus 2) of elements or chunks of elements. Broadbent (1971:4) also argues for limitations in the sense of a fixed number of items but assumes that the underlying number is more closely to *three*. And Baddeley (1990: 74, 1994: 355) tends to replace any sort of fixed-number limitations by time related limitations. The arguments of Schweickert & Boruff (1986:424) cited under our Thesis 2 is in line with this time based approach. Our findings, however, are in line with both approaches, the chunk based as well as the time based approach. Provided that one succeeds in choosing measures relevant for rhythmic processing (number of syllables per clause), time based limits and chunk based limits coincide: A time span of two seconds (plus minus one) comprises seven (plus minus two) syllables - from five rather complex syllables up to nine or even ten very simple syllables. This span of (about two seconds and) about seven syllables has, according to our findings, the appropriate size for encoding one proposition. In this respect our empirical results seem to have some impact on the propositional theory for sentence processing (Kintsch 1974) and on approaches connecting short-term memory with conscious processing. The span has the appropriate size that allows to extract the meaning of a clause before moving to the following clause. It has, to use Mandler's (1975:236) words, the size that can be kept within the conscious field, the focal attention.

Last but not least the empirical results conform to our theory of a relatively constant or invariant flow of information in natural languages. Frequently used linguistic units are shorter or get shorter (e.g. Zipf 1929, Mańczak 1980, Fenk-Oczlon 1989, Fenk-Oczlon in press) and these shorter units contain, because of their higher relative frequency, a lower amount of information. More complex entities transmit, approximately proportionate to their longer duration, more information than less complex entities. This seems to be valid not only on the word level (Fucks 1964, Fenk & Fenk 1980), but, as the results reported show, also on the level of more or less complex syllables.

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