Syntax is the Key to Memorizing Long Sentences: The Role of Brain Oscillations

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Sentence comprehension requires the encoding of sentences into working memory. Despite the functional significance of neural oscillations for language comprehension, the neural oscillatory dynamics of sentence encoding are only sparsely understood. While alpha– and beta-band oscillations have been reported both for verbal encoding outside the sentence-processing domain (Hanslmayr, Spitzer, & Bauml, 2009) and for sentence processing (Lewis, Schoffelen, Schriefers, & Bastiaansen, 2016), it is unclear to what extent these frequency bands subserve general verbal processes or processes specific to sentence comprehension. In the present study, we first hypothesized that alpha– and beta-band power changes are associated with successful sentence encoding. We employed a subsequent memory paradigm (e.g., Paller & Wagner, 2002), contrasting oscillatory power changes during the encoding of successfully-remembered versus later-forgotten sentences. We measured the scalp electroencephalogram of 24 healthy German-speaking young adults during the encoding of sentences, each consisting of two clauses and 17 words in total. Participants' encoding success was assessed via a subsequent, naturalistic retrieval task. Sensor-level time–frequency analysis showed that successful sentence encoding was associated with alpha– and beta-power desynchronizations that were source-localized to dorsal left-hemispheric language areas, as well as bilateral frontal regions, respectively. As encoding of long sentences necessitates the formation of a syntactic structure for memorization, we post-hoc hypothesized that the syntactic structure of the to-be-encoded sentences could help in dissociating the functional role of the two affected frequency bands. Strikingly, single-trial analysis of source-power time courses revealed that sentence encoding and comprehension were successful only when alpha-power desynchronization tracked the sentences' gross syntactic structure. In contrast, the time course of beta-power desynchronization did not relate to syntactic structure; in addition, our beta-power cortical generators have been related to mentalization of action roles. Thus, our beta-band effect likely reflects domain-general processes for the construction of sentence-level meaning (Kandylaki et al., 2016; Weiss et al., 2005). Our findings suggest that memory encoding of long sentences requires a structural representation to keep processing within capacity limits, the formation of which is subserved by alpha-band power desynchronization. Alpha– and beta-power desynchronizations are fingerprints of dissociable sentence-level language-specific syntactic and domain-general semantic processes, respectively.

References

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