Manipulating syntax without taxing working memory:
MEG correlates of syntactic dependencies in a Verb-Second language

Simone M. Krogh & Liina Pylkkänen, New York University

Querying the neural bases of syntax is difficult since syntactic manipulations often also tax working memory and introduce lexico-semantic confounds. Here we tackle both challenges in a study of Danish syntactic dependencies. First, we utilize two-word Danish yes/no questions, formed from declarative Subject-Verb sentences with a word order swap (Verb-Subject) while keeping the lexical material constant. We also vary argument structure by including verbs hypothesized to trigger argument-movement (unaccusatives and alternating unaccusatives; Perlmutter, 1978), and ones that do not (unergatives) (Table 1). Second, we use Rapid Parallel Visual Presentation (RPVP; Snell & Grainger, 2017) as our stimulus delivery method. In this approach, a full sentence is presented at once, for just a few hundred milliseconds (Figure 1). RPVP served to eliminate working memory-related costs and additionally allowed us to investigate the neural bases of the so-called Sentence Superiority Effect observed in prior RPVP literature. This effect refers to the advantage in rapid processing observed for structured vis-à-vis unstructured representations.

We showed our two-word sentences and control two-verb lists for 300ms in a simple matching task during a magnetoencephalography (MEG) recording (n = 29). Given the novelty of RPVP, we performed spatiotemporal clustering analyses in liberal search areas—bilateral full-hemisphere searches across the entire epoch (0–800ms) as well as bilateral lobe-by-lobe searches in early (100–500ms) and late (500–800ms) time windows—to maximally capture the effects of our manipulations. The early time window targeted the N400-like Sentence Superiority Effect reported by Wen et al. (2019) while the later time window was motivated by the P600 literature on syntactic processing (Kaan et al., 2000; Gouveau et al., 2010).

Our results show a behavioral and a neural Sentence Superiority Effect, realized as faster and more accurate matching responses for sentences than lists and a left fronto-temporal activity increase (231–407ms) for sentences (Figure 2). Our argument structure manipulation had a largely concurrent impact on right fronto-medial areas, showing higher activity for unergative verbs compared to unaccusative and alternating unaccusative verbs (Figure 3a). Later, we observed two syntactic frame effects; one with more activity for declaratives than yes/no questions (500–555ms) and a second one with the opposite directionality (638–723ms) (Figure 3b-c).

Our findings provide support for differential processing as a function of displacement and suggest a temporal ordering in which dependencies low in the syntactic tree are resolved before those high in the syntactic tree. Notably, however, none of our syntactic dependency effects localized in traditional syntactic hubs, e.g., the left inferior frontal gyrus (Stromswold et al., 1996) or the left posterior temporal lobe (Matchin & Hickok, 2020; Matar et al., 2021). The neurobiology of displacement may thus differ significantly from conventional perspectives when dissociated from covarying factors typically associated with serial stimulus presentation.

Table 1.

Composition (COMP)	Syntactic frame (SYN)	Argument structure (ARG)	Example	Gloss
Sentence	Declarative	Unergative	pigen festede	*'the girl partied'*
List	Declarative	Unergative	udgav festede	*'published partied'*
Sentence	Yes/no question	Unergative	festede pigen	*'did the girl party'*
List	Yes/no question	Unergative	festede udgav	*'partied published'*
Sentence	Declarative	Unaccusative	pigen vågnede	*'the girl awoke'*
List	Declarative	Unaccusative	udgav vågnede	*'published awoke'*
Sentence	Yes/no question	Unaccusative	vågnede pigen	*'did the girl awake'*
List	Yes/no question	Unaccusative	vågnede udgav	*'awoke published'*
Sentence	Declarative	Alternating unaccusative	pigen tørrede	*'the girl dried'*
List	Declarative	Alternating unaccusative	udgav tørrede	*'published dried'*
Sentence	Yes/no question	Alternating unaccusative	tørrede pigen	*'did the girl dry'*
List	Yes/no question	Alternating unaccusative	tørrede udgav	*'dried published'*

Figure 1.

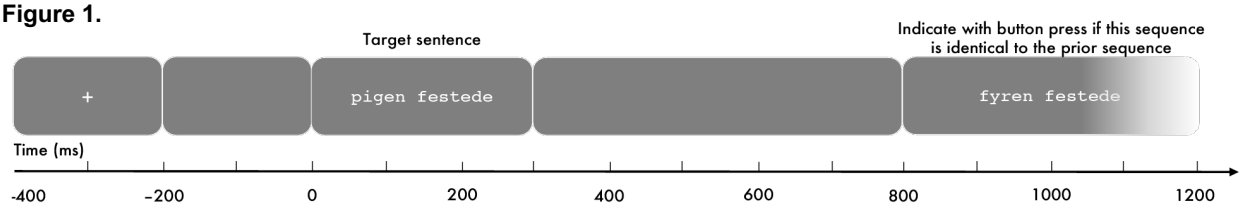

Figure 2.

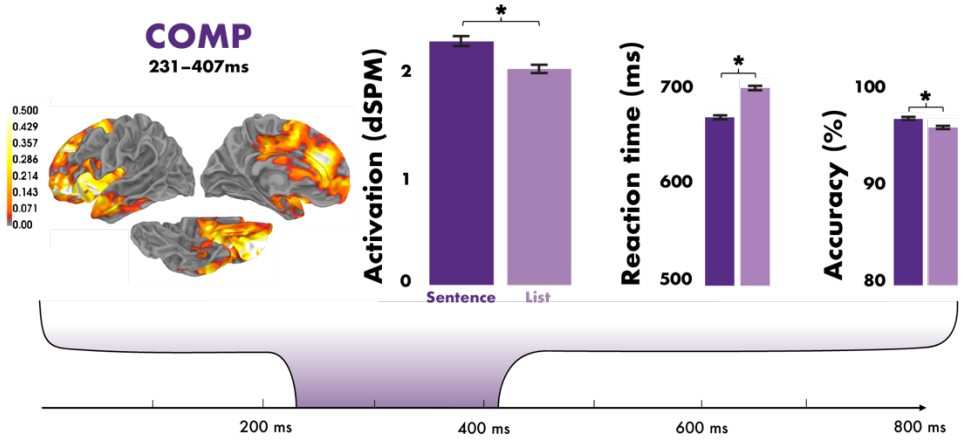

Figure 3.