ERP Responses to Syntactic Violations in Determiner Phrases

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In one of the most influential neurocognitive models of sentence comprehension, Friederici [1-2] posits that incremental sentence processing consists of phases applied to each word, with each indexed by distinct ERP effects. In the first stage, phrase structures are built based solely on syntactic category information. Disruptions to this automatic initial parse are indexed by an early left anterior negativity (ELAN) – a negative-going voltage shift that occurs 100-300 ms after stimulus onset and that is often maximal over left frontal scalp sites. In a later stage, multiple sources of information are integrated and the initial analysis of the sentence is revised if necessary. Processing difficulty at this stage is indexed by a positive shift 500-1000 ms after stimulus onset – a P600 effect. This effect relates in part to syntactic processing in that it is typically elicited along with ELAN effects and on its own in sentences involving agreement violations, structural ambiguity, and long-distance syntactic dependencies, among other structures [3]. The present study examines these stages of syntactic processing. The key question is whether there is clear evidence for an early negativity that is elicited by violations related specifically to low-level phrase structure building operations. This question is important because this ELAN effect underpins the staged, syntax-first model of sentence processing sketched above. It is also important considering recent work that has cast doubt on the ELAN effect and its functional significance [4-5].

In light of these issues, this study investigated the ERP responses elicited by two different syntactic violations in English determiner phrases (DPs). The first of these violations – illustrated in the Double Determiner sentences in (1) – involves adjacent determiners that prevent the construction of a licit DP. Under the staged model of sentence processing discussed above, it was predicted that the critical word in ungrammatical sentences (1a) would elicit an ELAN effect followed by a P600 effect. The second type of violation – illustrated in the Agreement sentences in (2) – involves number marking on a noun that mismatches with an immediately preceding quantifier. It was predicted that this violation would elicit a P600 effect at the critical word, but not an ELAN, since it does not prevent the formation of a viable phrase structure.

Native speakers of English (*N*=50) read Double Determiner and Agreement sentences (100 items per sentence type) in a Rapid Serial Visual Presentation paradigm (500 ms per word) while continuous EEG was recorded from 32 scalp sites. ERP waveforms were calculated for each condition time-locked to the presentation of the critical word. Grand average waveforms from representative electrodes and topographic maps reflecting voltage differences between ungrammatical and grammatical conditions for each sentence type are presented in the figure below. Mean voltage amplitudes in four time windows -- 100-300 ms, 300-500 ms, 500-700 ms, and 700-900 ms – were analyzed in linear mixed-effects regression models with sentence type (Agreement, Double Determiner), grammaticality (grammatical, ungrammatical) and two topographic factors – laterality (left, right) and position (anterior, posterior) – as fixed effects. In the 100-300 ms time window, there was a significant interaction of sentence type and grammaticality. Ungrammatical sentences were more negative than their grammatical counterparts, but only for Double Determiner sentences. In both the 500-700 ms and 700-900 ms time windows, there were reliable interactions involving sentence type, grammaticality, and the two topographic factors. Ungrammatical sentences were more positive than their grammatical counterparts for both sentence types; however, this effect (i) was larger in Double Determiner sentences and (ii) was most pronounced over posterior scalp sites for Double Determiner sentences and over posterior and right hemisphere scalp sites for Agreement sentences.

In sum, while the Double Determiner sentences elicited both an early negativity and a P600 effect, Agreement sentences elicited only a P600. These findings are therefore consistent with the idea that the ELAN effect relates specifically to disruptions to low-level phrase structure building operations. In this way, this study both clarifies the functional significance of the ELAN and provides support for syntax-first models of incremental sentence processing.

Example sentences (with critical words underlined)

(1a) *The musicians met with the <u>their</u> fans who won the contest.
(1b) The musicians met with the <u>three</u> fans who won the contest.
(2a) *Jeremy looked at several <u>bike</u> in the store before choosing one.
(2b) Jeremy looked at several <u>bikes</u> in the store before choosing one.

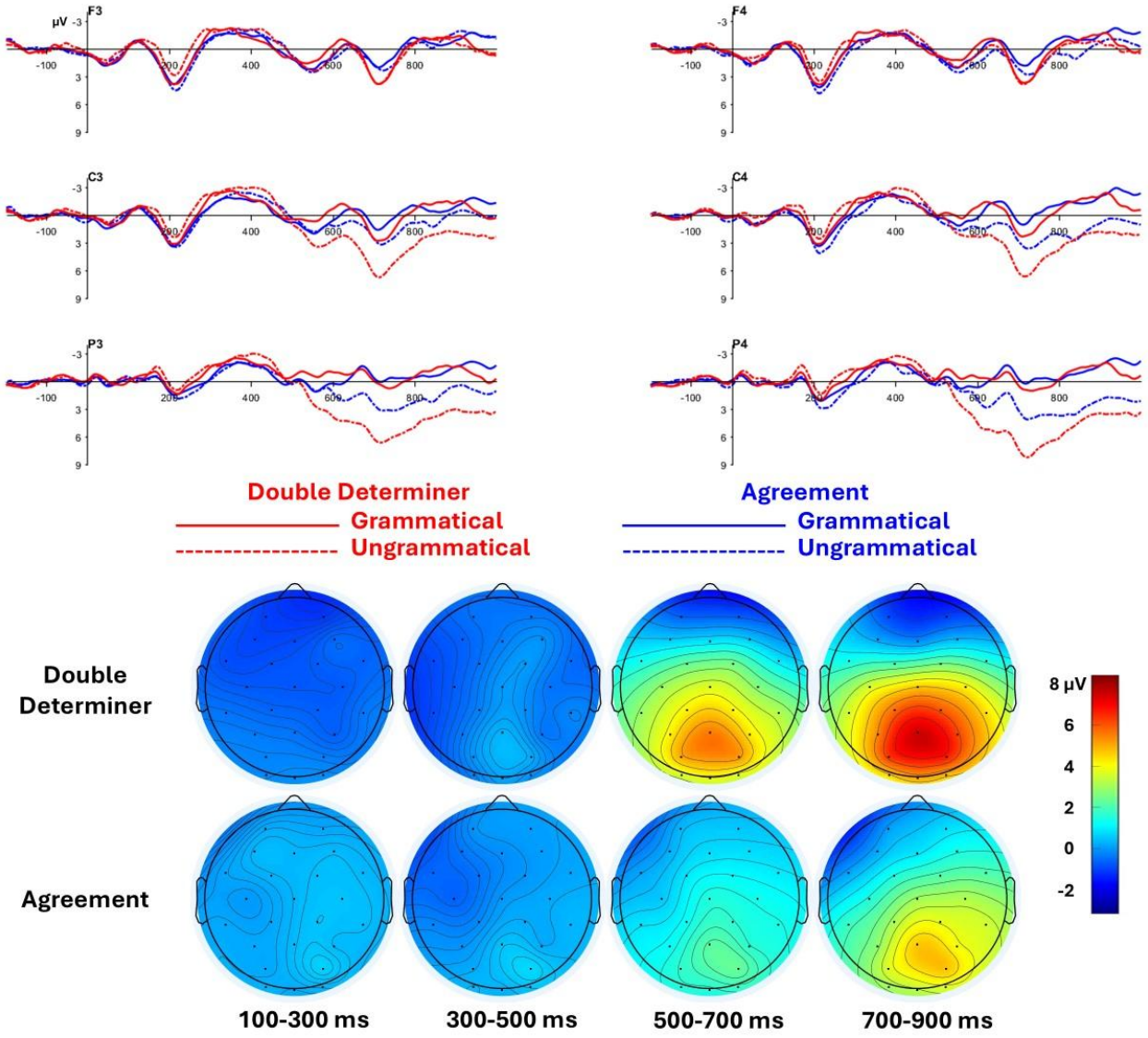

Figure. Grand average waveforms from representative electrodes and topographic maps reflecting voltage differences between ungrammatical and grammatical conditions for each sentence type.

References

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