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# Do discourse global coherence and cumulated information impact on sentence syntactic processing? An event-related brain potentials study

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ABSTRACT

The present study aimed at exploring how two main primarily semantic factors of discourse comprehension, namely global coherence and amount of information cumulated across a passage, may impact on the sentential syntactic processing. This was measured in two event-related brain potentials (ERP) to grammatical (morphosyntactic) violations: anterior negativities (LAN) and posterior positivities (P600). Global coherence did not yield any significant effects on either ERP component, although it appeared advantageous to the detection of morphosyntactic errors. Anterior negativities were also unaffected by the amount of cumulated information. Accordingly, it seems that first-pass syntactic processes are unaffected by these discourse variables. In contrast, the first portion of the P600 was significantly modulated (increased) by the latter factor. This probably reflects bigger efforts to combine sentential information during situations highly demanding for working memory. Our results would suggest that processes involved in global discourse coherence appear relatively independent of the on-line syntactic and combinatorial mechanisms reflected in the LAN and the P600 components of the ERPs.



## 1. Introduction

Reading a sentence is a complex process in which several types of information concur and have to be analyzed in very short time. One of the open debates in psycholinguistics concerns how conceptual/semantic and syntactic information exactly interplay during these processes. In this regard, several models have been proposed on the nature and functional characterization of syntax and semantics. On the one hand, strongly modular models assume that informationally encapsulated, and at least partly sequential processes, construct distinct syntactic and semantic representations of the

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sentence (e.g., Ferreira and Clifton Jr., 1986). On the other hand, fully interactive models suggest that syntactic and semantic constraints interact directly and simultaneously with each other in this process (e.g., McClelland et al., 1989). In between, intermediate perspectives also exist, differing in the degree of independence and prevalence attributed to the semantic and the syntactic domains (e.g., Kim and Osterhout, 2005).

The high temporal resolution of event-related potentials – ERP – and their suitability to approach linguistic processes as they unfold over time, make them ideally suited for studying sentence processing. Indeed, distinct ERP components have been described that substantiate the distinction between syntactic and semantic processing. In the syntactic domain, the main ERP effects are anterior negativities and posterior positivities. The former, typically labeled as LAN – left anterior negativity – after their leftmost usual distribution, peak roughly between 250 and 550 ms, although the so-called ELAN – early LAN – may appear as early as 100–200 ms. Word category violations are the variations most frequently associated with ELAN (e.g., Friederici and Mecklinger, 1996), whereas other grammatical anomalies, including morphosyntactic violations (e.g., Coulson et al., 1998), usually elicit a LAN. Anterior negativities may reflect highly automatic first-pass parsing processes, the detection of a morphosyntactic mismatch, higher syntax working memory load, and/or the inability to assign the incoming word to the current phrase structure (Friederici, 2002; Gunter et al., 1997; Kluender and Kutas, 1993). Regarding the posterior positivities, a late positive component peaking at parietal sites and labeled P600 has classically been considered as a syntax-related ERP fluctuation, since it is typically elicited by syntactic violations and structurally ambiguous but correct sentences (Frisch et al., 2002; Osterhout and Holcomb, 1992). Accordingly, the P600 would indicate increased syntactic processing costs due to revisions and reanalyses of sentential structural mismatches, possibly also reflecting subsequent repair processes (Münte et al., 1998). The occasional P600 deflections to semantic violations (e.g., Kuperberg et al., 2003; Kolk et al., 2003; Hoeks et al., 2004; Kim and Osterhout, 2005) have also motivated an alternative interpretation of the P600, such as the reflection of the activity of a combinatorial system that integrates both semantic and syntactic information (Kuperberg, 2007), or a domain-general monitoring mechanism (Kolk and Chwilla, 2007).

Concerning the semantic domain, a systematic finding is the so-called N400 component (Kutas and Hillyard, 1980), a negative fluctuation resembling the LAN in latency and usually peaking at central and posterior sites (Kutas and Besson, 1999). Some authors have proposed that the N400 reflects post-lexical integration processes (Chwilla et al., 1995). An alternative perspective, however, characterizes the N400 as indexing the efforts of accessing long-term multimodal lexico-semantic memory (Kutas and Federmeier, 2011).

The distinction between syntax- and semantics-related ERP, however, has not been demonstrated to be unequivocal. As mentioned, particular semantic manipulations have been able to yield modulations in components typically considered as syntax-related. Similarly, syntactic manipulations in certain experiments have been able to modify the typical semantic N400 component (e.g. Bornkessel et al., 2004; Choudhary et al., 2009; Haupt et al., 2008). Despite these exceptions, nevertheless, the overall distinction and assumptions for these components still hold and are highly valuable in the study of language comprehension.

A large body of evidence from the ERP seems to support a "syntactocentric" view, in which syntactic information would be highly encapsulated, prevailing over and affecting semantic processing with no influence in the opposite direction (e.g., Friederici, 2002, 2004). This view is largely supported by studies using double violations – containing both syntactic and semantic anomalies simultaneously – usually yield an ELAN or a LAN and a P600. In these manipulations the N400 is either absent (e.g., Friederici et al., 1999) or significantly modulated – for example, boosted (Hagoort, 2003). However, several studies have also reported no effects of syntactic manipulations on semantic processing (e.g., van den Brink and Hagoort, 2004), or even a "semantocentric" direction of the effects (e.g., Gunter and Friederici, 1999; Martín-Loeches et al., 2006, 2012), demonstrating that semantic information may actually prevail or at least modulate syntactic processing under certain circumstances. A relevant line of research studying the syntax–semantics interplay has used pseudowords or "jabberwocky" sentences (Carroll, 1883) to create contexts devoid of semantic content. Results suggest that in jabberwocky sentences, as in normal sentences, it is possible to perform an early syntactic processing – reflected in the presence of anterior negativities – followed by a blocking of subsequent semantic integration processes in case of syntactic anomaly, this presumably supporting the syntactocentric view (Hahne and Jescheniak, 2001). Even though, the neural substrates of the syntactic processing in jabberwocky sentences might not be exactly the same as in regular ones because of a different distribution of the effects (Canseco-Gonzaléz, 2000; Yamada and Neville, 2007). Further, amplitude reductions of the P600 for jabberwocky in comparison to regular sentences (Canseco-González, 2000; Münte, 1997; Yamada and Neville, 2007) have led some authors to suggest that the P600 may be reflecting processes of reanalysis in which both syntactic and semantic domains interplay; the absence of semantic information would prevent the linguistic system from performing these reanalyses.

The debate on the interplay between syntax and semantics reviewed above might turn out yet more complicated when dealing with discourse comprehension. This approach actually enables a more ecologically valid and natural situation than the typical use of single, unconnected sentences. Discourse processing involves a number of active processes normally absent or much reduced during single, isolated sentence processing. In this regard, both information provided by the text – or utterance – and from long-term memory are brought by the reader – or listener – to interplay during discourse comprehension, yielding a mental representation of the described situation, i.e., a "mental model" or "situation model" (Johnson-Laird, 1983; van Dijk and Kintsch, 1983). At this level, readers or listeners activate knowledge that goes beyond the text, filling-in gaps and running mental models by means of inferences (Kim et al., 2012). Discourse coherence is built as based on the semantic connections between its elements – propositions and inferences (Wolfe, 2005).