



Morphosyntactic integration in French sentence processing: Event-related brain potentials evidence

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ABSTRACT

The present event-related brain potentials (ERP) study investigated the online integration of morphosyntactic information in auditory French sentences using a violation paradigm. Two main factors were manipulated: (1) The degree of complexity of the morphosyntactic violation, (2) The moment when the agreement violation occurs within the sentence. Both types of morphological agreement violations (intra/inter) elicited a biphasic anterior negativity/P600 ERP pattern. However, the amplitude of this pattern was larger for the interphrasal violation than for the intraphrasal one. This result suggests an easier detection but a more costly integration when the agreement violation occurs between elements belonging to different syntactic units. Moreover, an effect of position was observed but only when the violation concerned elements of a single syntactic unit. Taken together, the present findings suggest that morphological integration may be modulated by both the complexity of morphosyntactic agreement and the moment at which it takes place during the course of sentence processing.

1. Introduction

Auditory sentence comprehension requires the rapid integration of multiple sources of linguistic information such as phonological, morphological, syntactic and semantic ones. Because all this information must be accessed and coordinated within milliseconds, the functional dissociations within the neural basis of auditory sentence processing are difficult to specify. Linguistically, a crucial part in the process of sentence comprehension is the assignment of grammatical relations. To understand who is doing what to whom, semantic features (e.g., animacy) as well as morphosyntactic features (e.g., subject-verb agreement, case marking, etc.) have to be analyzed. The present study focuses on the effect of sentential structural constraints on morphosyntactic agreement, a linguistic phenomenon of central interest in sentential units' dependency. Agreement is defined as the “systematic covariance between a semantic or formal property of one element and a formal property of another” (Steele, 1978), and involves the variation of three main features, i.e., Number, Gender and Person (Wechsler, 2009). It is a phenomenon observable in about 50% of languages (according to Bybee, 1985).

The main assumption of our work is that the processing system tries to assign linguistic cues to meanings as soon as possible, integrating each element of linguistic information into larger structures compatible with the information obtained up to that point. In this processing view, attachments between units that can be made locally (e.g., article-noun agreement) place less load on the processor than attachments between units belonging to different NPs (e.g., subject-verb agreement). Furthermore, we hypothesized that the more the quantity of linguistic information provided by the sentence increases, the more the structural constraints of the

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sentence increase, which results in putting the language processing system in a more efficient condition for rapid integration. Until now, little is known on how expectations of ongoing information built in real time from the sentential context under construction may impact the processing of morphosyntactic agreement.

Previous behavioral developmental studies in various languages (for a review, Kail, Kihlstedt, & Bonnet, 2012, Kail, Lemaire, & Lecacheur, 2012) using the violation paradigm have shown that online sentence processing is influenced by (1) the type of attachment between units, that is to say depending whether the elements belong to the same constituent (intra-phrasal; for example, gender agreements within NP) or to different main constituents (inter-phrasal; for example, verbal agreement), and (2) the point where the agreement violation occurs in the sentence. Globally, intraphrasal morphosyntactic violations are detected more accurately and more rapidly than interphrasal ones; violations occurring in late position within the sentence are more accurately and more rapidly detected than early ones.

In the literature on agreement, Event-Related Potential (ERP) research on sentence comprehension, focusing on the different dimensions of agreement patterns converge to show that the processing of morphosyntactic violations are usually associated with a biphasic electrophysiological pattern (Left Anterior Negativity – LAN, 300–450 msec and P600 after 500 msec; for a review, see Molinaro, Barber, & Carreiras, 2011). While the LAN is thought to reflect an early detection of morphosyntactic mismatch, the P600 is assumed to reflect a repair processes (for a review, see Friederici, 2011). Unfortunately, the dissociation between these processes is not possible in online reaction time studies, which are not exactly time-locked with the stimulus and cannot therefore capture the dynamics of the processing at the millisecond level. On the contrary, electrophysiological methods of ERP measures used in the present study provide the crucial timing information.

The research question we addressed here was to determine whether the type of attachment between units (intra phrasal vs. inter phrasal) and the point where the agreement violation occurs within the sentence impact the detection and integration processes. If so, the LAN/P600 ERP pattern should be modified as a function of type of attachment and position violation in the sentence. We approached this question using spoken French sentences. To date, most of the studies having investigated the role of grammatical anomalies position within sentences have focused on violation of selectional restriction at the semantic level (for a review, see Kutas & Federmeier, 2007, 2011). Therefore, our study constitutes a first attempt to extend this issue using another linguistic phenomenon, namely morphosyntactic agreement. Moreover, only a few studies have examined processing of morphological agreement in French, and most of them were conducted with written stimuli (Foucart & Frenck-Mestre, 2011; Frenck-Mestre, 2004; Frenck-Mestre, Osterhout, McLaughlin, & Foucard, 2008).

Most neurocognitive models of sentence processing postulate that morphosyntactic agreement analysis is signed by a LAN and/or P600 ERP response (Friederici, 1995, 2002; Hagoort, 2003, 2005; for a discussion at the behavioral level, see also the Competition Model proposed by Bates & MacWhinney, 1987, 1989; Kail, 2012). Recently, Molinaro et al. (2011) proposed a neurocognitive model of the temporal and neural dynamics of grammatical agreement processing in reading based on electrophysiological data. In this model, the LAN could reflect violation of expectancy elicited by a word (the trigger) for the functional morphology of another word (the target) connected to it. At a later stage, trigger and target are structurally integrated at the sentence level. This integration process is thought to be reflected by an early P600. Interestingly, Molinaro et al. (2011, p. 908) also claim that « morphosyntactic information could trigger the activation of higher-level representations that are not strictly syntactic in nature. The recruitment of this additional non-syntactic information (mirrored by N400-like effects) indicates that rule-based computations of agreement dependencies are not blind to non-syntactic information but are often recruited to establish sentence-level relations. ».

1.1. Empirical data

In the literature on agreement, most of the electrophysiological studies on *subject–verb* number agreement dependencies conducted in different languages with different populations reported a LAN followed by a P600 (for a review see Molinaro et al., 2011). In contrast, nominal agreements elicit more different ERP patterns.

1.1.1. Nominal and verbal agreement

At the formal level, the distinction between nominal agreement and verbal agreement refers to the complexity of syntactic attachment: low attachment for nominal agreement, higher attachment for verbal agreement.

1.1.1.2. Nominal agreement: gender article-noun agreement

In their seminal study, Münte and Heinze (1994) found LAN effects in response to gender article-noun violations in different languages (German, English and Finnish) and with different tasks (grammatical judgment and lexical decision). This effect was also replicated in German (Wedel & Hahne, 2002) as well as in Spanish (Barber & Carreiras, 2005; Caffarra, Janssen, & Barber, 2014). Nevertheless, some other studies only found a P600 (also called Syntactic Positive Shift, SPS) component in response to article-noun gender violations (Dutch: Hagoort & Brown, 1999; French: Frenck-Mestre, 2004; Foucart & Frenck-Mestre, 2011; Spanish: Wicha, Moreno, & Kutas, 2004; Gillon-Dowens, Guo, Guo, Barber, & Carreiras, 2011). However, the exact functional role of the P600 in the case of agreement violations remains disputable. One hypothesis is that this ERP component may reflect morphosyntactic reanalysis/repair (for a discussion on the functional role of the P600, see Friederici, 2011, but also Shen, Fiori-Duharcourt, & Isel, 2016). Surprisingly, the processing of agreement violation between an article and a compound word was associated with a biphasic N400–P600 ERP (German: Isel & Friederici, 2005; Isel, 2010; Spanish: Barber & Carreiras, 2003, 2005). To sum, in the literature of morphosyntactic agreement, most of the researchers found that the LAN/P600 ERP pattern may constitute the most likely pattern of

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