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Similarities and differences between phrase structure and morphosyntactic violations in Spanish: An event-related potentials study

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Event-related potentials (ERPs) were employed to compare word category and verb inflection violations in Spanish. A similar frontal negativity was found between 250–400 ms for both violation types, suggesting that they equally disrupt initial syntactic analyses. Also, word category violations elicited a negativity at posterior electrodes larger than verb inflection anomalies and correct sentences within this time window, probably reflecting difficulties to semantically analyse phrase structure violations. Finally, a centroparietal positivity in the 500–700 ms interval was found for both error types. Both violations did not differ along the first half of this interval (500–600 ms), but larger effects for verb inflection violations were reported along

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the second half of this period (600–700 ms). These findings suggest that whereas processes dealing with the reanalyses of sentence structure are equally triggered by both anomaly types, further attempts of repairing the structure of sentences occur only with verb inflection violations.

INTRODUCTION

Syntax refers to the structure of the relationships that exist between the constituents (words, clauses, sentences . . .) of an utterance. Among other aspects of language, including semantics, prosody, or pragmatics, it constitutes a necessary process in order to correctly interpret or produce enunciates. In this regard, syntactic processing is one of the central issues in psycholinguistic research. Different behavioural measures have been traditionally used in order to explore syntactic processing. In this regard the measurement of reaction times and the tracking of eye movements are the approaches most often used.

In recent years, however, the use of neuroimage techniques has generalised to the study of syntax. On the one hand, several studies have been concerned with the location of brain structures implicated in different aspects of syntactic analyses by means of positron emission tomography and functional magnetic resonance imaging measures. On the other hand, a different approach has attempted to investigate the temporal course of the processes involved in syntax. The use of event-related potentials (ERPs) has proved to be of particular interest when addressing these issues by means of two ERP responses that have repeatedly shown to correlate with different aspects of syntactic processing. We will present previous data about these components separately.

Early anterior negativities

Most of the studies dealing with syntax have reported negativities between 200 and 600 ms after stimulus onset with a central and anterior scalp distribution, left-lateralised in most of the cases. These negativities have been typically labelled as LAN (left anterior negativity) or ELAN (early left anterior negativity) depending on their onsets and latencies. Word category violations, which disrupt the building of the phrase structure, are the anomalies most frequently associated with early anterior negativities (Ainsworth-Darnell, Shulman, & Boland, 1998; Friederici, Hahne, & Mecklinger, 1996; Gunter, Friederici, & Hahne, 1999; Hahne & Friederici, 1999; Neville, Nicol, Barss, Forster, & Garret, 1991). Early anterior negativities with different onsets and topographic distributions have also been shown to be evoked by other syntactic anomalies including violations of the subcategorisation properties of verbs (Coulson, King, & Kutas, 1998; Friederici & Frisch, 2000; Rösler, Pütz, Friederici, & Hahne, 1993), as well

as morphosyntactic violations such as number agreement, gender agreement, and verb inflection violations (Gross, Say, Kleingers, Clahsen, & Münte, 1998; Gunter, Friederici, & Schriefers, 2000; Hahne & Jescheniak, 2001; Penke, Weyerts, Gross, Zander, Münte, & Clahsen, 1997; Vos, Gunter, Kolk, & Mulder, 2001a; Weyerts, Penke, Dohrn, Clahsen, & Münte, 1997). However, all of these types of violations have also failed to elicit anterior negativities in other studies (Gunter & Friederici, 1999; Hagoort & Brown, 2000; Osterhout, Mckinnon, Bersick, & Corey, 1996; Rodriguez-Fornells, Clahsen, Lleó, Zaake, & Münte, 2001). Table 1 summarises the results of several studies that have included either phrase structure violations, morphosyntactic violations or both.

The functional significance of these anterior negativities has generated an intense debate. The most widely accepted view suggests that early anterior negativities reflect highly automatic first-pass parsing processes and the inability to assign the incoming word to the current phrase structure (Friederici, 1995; Hahne & Friederici, 1999; Friederici, Hahne, & Mecklinger, 1996). However, this proposal has been questioned by some authors who claimed for an interpretation of early anterior negativities in terms of working memory rather than syntactic processes, since these effects have been found for correct grammatical sentences taxing working memory. In support of this view, Weckerly and Kutas (1999) presented their subjects with two types of object relative sentences that varied in the order of the component animate and inanimate nouns [Inanimate (Animate) vs. Animate (Inanimate)]. These authors found an early anterior negativity between 200 and 500 ms to the main clause verbs of object relative sentences with an Animate (Inanimate) configuration, supposed to be the sentences more difficult to process. This effect was interpreted thereafter to reflect the high working memory load required by the processing of these sentences. Similar effects were previously reported by King and Kutas (1995) who found that verbs in object relative sentences showed early anterior negativities in the 300–500 ms time interval as compared to those in subject relative clauses. An additional study has shown that the amplitude of early anterior negativities is modulated by the complexity of the syntactic structure of the sentences, the working memory load and the working memory span of the individuals (Vos, Gunter, Kolk & Mulder, 2001a; but see Gunter, Stowe & Mulder, 1997). Finally, a third point of view about the functional significance of the early anterior negativities considers that these effects reflect the involvement of structural transformation rules that allow prediction of the subsequent organisation of a sequence. The presence of an early anterior negativity in the 400-600 ms time interval that was elicited by words as well as by non-linguistic symbols has been taken as evidence supporting this perspective (Hoen & Dominey, 2000).

TABLE 1
Summary of the results of studies taken from the literature concerning the ERP effects to phrase structure and morphosyntactic violations. 'Language' refers to the language in which sentences were presented; 'P' = positive; 'N' = negative.

Reference	*Language*	*Type of violation*	*ERP effects (polarity, latency, distribution)*
Kutas & Hylliard, 1983	English	(1) Verb number	(1) N200–400, left frontal + late parietal positivity
		(2) Noun number	(2) N200–500, frontal + late parietal positivity
		(3) Verb tense	(3) N300–400, central + late parietal positivity
Neville et al., 1991	English	Phrase structure	N125, left frontal + N300–500, temporal-parietal
Osterhout & Holcomb, 1992	English	Phrase structure	N400, central-parietal + P400–900, parietal
Hagoort et al., 1993	Dutch	Subject-verb agreement	P500–700, central-parietal
		Phrase structure	P500–700, central-parietal
Friederici et al., 1993	German	Verb inflection	N300–600, frontal-central + P600–1200, parietal
Osterhout & Mobley, 1995	English	Expt 1	Expt 1
		(1) Subject-verb number agreement	(1) N300–500, left anterior + P500–800, right parietal
		(2) Reflexive-antecedent number agreement	(2) P500–800, widely distributed
		(3) Reflexive-antecedent gender agreement	(3) P500–800, widely distributed
		Expt 2	Expt 2
		(1) Pronoun-subject gender agreement	(1) P500–800 central-parietal (only when subjects judged sentences to be unacceptable)
		Expt 3	Expt 3
		(1) Subject-verb number agreement	(1) N50–150, central + P500–800, widely distributed
		(2) Reflexive-antecedent number agreement	(2) No differences from controls
		(3) Reflexive-antecedent gender agreement	(3) No differences from controls
Friederici et al., 1996	German	Expt 1	Expt 1
		Phrase structure	N400–600, left frontal + P800–1200, central-parietal

		Expt. 2	Expt 2
		Phrase structure	N350–500, left frontal + P500–1000, parietal + N700–1200, left frontal
Osterhout et al., 1996	English	Subject-verb agreement	P500–800, parietal
Gunter et al., 1997	Dutch	Expt 1	Expt 1
		Verb inflection	P600–1000, central-parietal
		Expt 2	Expt 2
		Verb inflection	N160, left frontal + N250–500, left frontal + P600–1000 widely distributed
		Expt 3	Expt 3
		Verb inflection	N250–400, left frontal + P600–1000 central-parietal
Penke et al., 1997	German	(1) Regular verbs inflection	(1) No differences from controls
		(2) Irregular verbs inflection	(2) N250–500, frontal and temporal
Munte et al., 1998	German	Case inflection	N300–500, frontal-central + P600–1200, central-parietal
Ainsworth-Darnell et al., 1998	English	Expt 1	Expt 1
		Phrase structure	P700–950, central-parietal
		Expt 2	Expt 2
		Phrase structure	P500–950, central-parietal
Coulson et al., 1998	English	Expt 1	Expt 1
		Subject-verb agreement	N300–500, right central-parietal + P500–800 central-parietal
		Expt 2	Expt 2
		Pronoun inflection	N300–500, left frontal-central + P500–800 central-parietal
Hahne & Friederici, 1999	German	Phrase structure	N100–300, left frontal + P500–1000, central-parietal
Gunter & Friederici, 1999	German	(1) Verb inflection	(1) N300–500, central + P550–800, widely distributed
		(2) Phrase structure	(2) N300–500, central-parietal + P550–800, widely distributed

(Continued overleaf)

TABLE 1 (Continued)

Reference	*Language*	*Type of violation*	*ERP effects (polarity, latency, distribution)*
Friederici, et al., 1999	German	Phrase structure	P500–800, central-parietal
Gunter et al., 1999	German	(1) Phrase structure (easy word discrimination)	(1) N100–150, left-frontal + P500–900, parietal
		(2) Phrase structure (difficult word discrimination)	(2) N450–500, left-frontal + P500–900, parietal
Demestre et al., 1999	Spanish	Noun-adjective gender agreement	N150–250, frontal-central + P250–500, widely distributed
Hagoort & Brown, 2000	Dutch	Expt 1	Expt 1
		(1) Subject-verb number agreement	(1) P500–750, widely distributed + P750–1000, parietal
		(2) Phrase structure	(2) P500–750, widely distributed + P750–1000, parietal
		Expt 2	Expt 2
		(1) Subject-verb number agreement	(1) N300–550, frontal + P500–1250, parietal
		(2) Phrase structure	(2) P500–750, widely distributed + P750–1000, parietal
Harris et al., 2000	English	Noun-pronoun number agreement	P550–750, central-parietal
Gunter et al., 2000	German	Article-noun gender agreement	N300–450, left frontal and central-parietal + P450–950
Kaan et al., 2000	English	Expt 2	Expt 2
		Subject-verb agreement	P500–900, left parietal
Hahne & Jescheniak, 2001	German	Phrase structure in regular and jabberwocky sentences	N100–250, frontal-central + P500–1000, central-parietal
Rodríguez-Fornells et al., 2001	Catalan	(1) Verb stem formation	(1) N300–550 central-temporal + P750–1250, parietal
		(2) Verb inflection	(2) P750–1250, parietal
Vos et al., 2001	Dutch	Subject-verb agreement	N250–450, frontal + P500–800, central-parietal

All these alternative interpretations provide a global theoretical framework that is useful when approaching issues concerning syntactic processing. However, they cannot account for the dispersion that has been found in both the latencies and the topographical distributions of the early negativities reported in the experiments mentioned above. Some authors have suggested that phrase structure violations typically elicit anterior negativities earlier in time (ELAN) than those evoked by morphosyntactic violations (LAN) (Gunter & Friederici, 1999). However, a careful inspection of the available literature does not always substantiate this conclusion. Thus, as Hagoort and Brown (2000b) noticed, it is not possible to conclude that all these findings can be subsumed under the heading of one ERP effect, and more experimentation is required to determine the functional significance of the early anterior negativities.

Late centroparietal positivities

The majority of the ERP studies that have investigated syntactic processing reported also a positivity between 500 and 1200 ms after stimulus onset with a centroparietal distribution, which has been termed P600 or Syntactic Positive Shift. These effects appeared either alone or were preceded by early frontal negativities similar to those described above in response to a wide variety of syntactic violations: phrase structure violations (Ainsworth-Darnell, Shulman & Boland, 1998; Gunter et al., 1999; Hagoort & Brown, 2000b), violations of verb subcategorization constraints (Osterhout & Holcomb, 1992; Friederici & Frisch, 2000; Hagoort & Brown, 2000b), violations of the structural preference in garden-path sentences (Osterhout & Hagoort, 1999; Osterhout & Holcomb, 1993; Osterhout, Holcomb & Swinney, 1994), violations of anaphoric relationships (Harris, Wexler & Holcomb, 2000), violations of constraints on movement (McKinnon & Osterhout, 1996; Nakagome et al., 2001), and morphosyntactic violations (Coulson et al. 1998; Gunter et al., 2000; Münte, Heinze, Matzke, Wieringa, & Johannes, 1998; Münte, Szentkuti, Wieringa, Matzke & Johannes, 1997; Osterhout & Mobley, 1995; Rodriguez-Fornells et al., 2001). P600 effects are also evoked by correct grammatical sentences that are less frequent or expected (Kaan, Harris, Gibson & Holcomb, 2000). Even though, a few studies failed to report P600 effects to syntactic violations (Penke et al., 1997; Weyerts et al., 1997) (see table 1).

The amplitude of the late centroparietal positivity has been suggested to reflect controlled processes of syntactic reanalysis and repair (Friederici et al., 1996; Friederici & Mecklinger, 1996; Hahne & Friederici, 1999), or the costs of reprocessing (Osterhout & Holcomb, 1992). However, it has been shown that semantic or orthographic violations elicited P600 responses

(Münte et al., 1998). Also, this component seems to be sensitive to prosody (Steinhauer, Alter & Friederici, 1999). All these data argue against the interpretation of the P600 as an index of purely syntactic reanalysis. It seems thus, that the P600 reflects a final stage of linguistic processing that takes into consideration different levels of linguistic information in order to test the correctness of the processes that have been undertaken, so a reanalysis process starts when needed. Another debate concerns the language specificity of the P600 component. We will just mention that several authors claim that this component is specific of language processing (Hahne & Friederici, 1999; Osterhout et al., 1996), whereas other authors assume that this response is more general and belongs to the P300 family (Coulson et al., 1998).

The present study

All in all, even though some general conclusions might be drawn, ERP studies on syntactic processing show a somewhat complicated picture. It seems that different syntactic violations do not lead to the same ERP responses and, which is more striking, the same violations do not always modulate ERP responses equally. More efforts are needed, thus, in order to improve this state of affairs.

One attempt of doing this can be made by studying the processing of syntactic aspects in different languages. It should be noticed that the research on syntax and ERPs has been conducted almost exclusively in English, German, and Dutch. Up to date, only one previous study has reported syntactic-related responses in Spanish by using ERPs methodology. In that study, Demestre, Meltzer, García-Albea, & Vigil (1999) investigated the coreference relation between a null subject and its antecedent by means of noun-adjective gender agreement violations with an auditory presentation. These authors reported an early negativity with a frontocentral topography followed by a centroparietal positivity.

Hence, syntactic processing has not been systematically studied in Spanish language with ERP methodology, which contrasts with the increasing amount of studies that have been recently conducted in other languages. Thus, the first aim of the present study is to provide further evidence about the presence of ERP modulations related to syntactic violations in Spanish with a visual presentation of the materials, which contrasts with the auditory modality used in the Demestre et al. study (1999). Beyond this objective, we aimed at investigating whether the processes involved in phrase structure building and those dealing with verb inflectional derivation have some features in common or are totally different. It should be noted that word category violations disrupt the building of the structure of the phrase, which affects primary parsing

processes, according to some views (Frazier, 1990; Gorrell, 1995). By contrast, verb inflection violations constitute morphosyntacic violations which are thought to disturb to a lesser extent syntactic processing. Studies that have included both verb inflection and phrase structure violations in their experimental designs are rather scarce and their results are not conclusive (Gunter & Friederici, 1999; Hagoort & Brown, 2000b; Hagoort, Brown, & Groothusen, 1993). All these studies reported P600 effects elicited by both anomaly types, in German and Dutch, and with visual and auditory presentations. However, no early anterior negativities were reported in these studies with the exception of verb inflection violations with auditory presentations in the Hagoort and Brown (2000b) work. Accordingly, no direct comparison between both types of syntactic violations could be performed despite the relevance that such a comparison would yield for the understanding of syntactic processing. Additionally, and importantly, it should be also noticed that neither of these violation types has been previously investigated with ERP in Spanish.

Hypotheses for the present experiment are as follows: both phrase structure and morphosyntactic violations were expected to elicit P600 effects on the basis of previous studies. By contrast, firm predictions could not be made with regard to the presence or absence of early negativities elicited by the two types of anomalies due to the divergent pattern of results reported in the literature.

METHODS AND MATERIALS

Participants

Thirty Spanish-speaking students (16 females, mean age 24.1 years, range 19–32) were paid for their participation in the experiment. They were right-handed, with average handedness scores of +75, ranging from +45 to +100 according to the Edinburgh Handedness Inventory (Oldfield, 1971). All participants had normal or corrected-to-normal vision. The data of two subjects were excluded because they were markedly contaminated by artefacts.

Stimuli

A total of 120 experimental sentences were constructed. All sentences contained seven words and had a similar two-clause structure. The subordinate clause was a passive abbreviate relative clause that was always embedded between the subject and the predicate of the main clause. All verbs were regular. Verbs of the main clause were conjugated in a past

tense. The structure was, thus, as follows (with an English literal translation):

La niña	[(que fue)	asombrada	por	el	regalo	]	sonrió
The girl	[(who was)	amazed	by	the	present	]	smiled
Det_1	$noun_1$	[$verb_2$	$prepos_2$	det_2	$noun_2$	]	$verb_1$

All words had a two to four syllables length with the exception of determinants and prepositions. From each of the sentences two further versions were made that contained either a phrase structure or a morphosyntactic error. The first type of error was realised by removing the noun of the abbreviate relative clause, so that the verb of the main clause immediately followed a determinant—the determinant of the relative clause—which constitutes a word category violation. Therefore, this type of sentences contained six words. The second type of error was a verb inflection violation realised by replacing a correctly conjugated verb (third person singular past tense) by an incorrectly conjugated verb (first person singular past tense). Correct and incorrect verbs had the same stem and only varied in their suffixes. The suffix of the correct verbs ended always in *o*, while suffixes of incorrect forms could end either in *e* or *i*. An example of each sentence type is given below (with literal English translations):

(1) Correct sentence
La prueba ocultada por el fiscal *apareció.*
The proof (that was) hidden by the public prosecutor (it) *appeared.*
(2) Word-category violation
* La prueba ocultada por el *apareció.*
* The proof (that was) hidden by the *appeared.*
(3) Verb-inflection violation
* La prueba ocultada por el fiscal *aparecí.*
* The proof (that was) hidden by the public prosecutor (I) *appeared.*

The sentence final verbs were the critical words to which ERP were measured. Sentences were allocated in three blocks. Each of these blocks had 40 correct sentences, 40 sentences with a word category error, and 40 sentences with a verb inflection violation, so none of the sentences was repeated within an experimental session. Of the 120 fillers included, one third were ungrammatical, so half of the sentences in an experimental session were grammatical and half ungrammatical. Each of the three experimental blocks was presented to ten subjects. Participants had to

perform a grammaticality judgement about the correctness of every sentence. They were instructed to press one of two buttons when the sentence was correct and the other button when the sentence was incorrect. They always used the right hand. All sentences had a word-by-word presentation format (300 ms per word with a 500 ms SOA). A fixation cross was presented 1000 ms after the presentation of the sentence-ending verb (period included). Participants were instructed to give their response after the fixation cross had appeared. The presentation of the next sentence started 1500 ms after the participants' response.

All stimuli were matched in visual aspects. They were presented white-on-black on a NEC computer MultiSync monitor, controlled by the Gentask module of the STIM package (NeuroScan Inc.). Subjects' eyes were 65 cm from the screen. At that distance, all stimuli were between 0.7° and 1.3° high, and between 1.1° and 6° wide.

Procedure

Participants were tested with one of the three blocks in a single experimental session that lasted for about one and a half hours. Task instructions were given to subjects and a practice block was allowed. The practice block did not include any of the experimental sentences. The experimental block was further subdivided in three sequences of 80 sentences, so two resting periods were allowed to participants within an experimental session. Subjects were explicitly told to blink when the fixation cross appeared.

Electrophysiological recordings

The electroencephalogram (EEG) was recorded with 59 tin electrodes that were embedded in an electrode cap (electroCap International). Scalp locations were: Fp1, Fpz, Fp2, AF3, AF4, F7, F5, F3, F1, Fz, F2, F4, F6, F8, FC5, FC3, FC1, FCz, FC2, FC4, FC6, T7, C5, C3, C1, Cz, C2, C4, C6, T8, TP7, CP5, CP3, CP1, CPz, CP2, CP4, CP6, TP8, P7, P5, P3, P1, Pz, P2, P4, P6, P8, PO7, PO3, PO1, POz, PO2, PO4, PO8, O1, Oz, O2 and left mastoid all referred to the right mastoid. These labels correspond to the revised 10/20 International System (1991), plus two additional electrodes, PO1 and PO2, located halfway between POz and PO3 and between POz and PO4, respectively. Bipolar horizontal and vertical electrooculogram (EOG) was recorded for artefact rejection purposes. Electrode impedances were kept under 3 KΩ. The signals were recorded continuously with a bandpass from 0.01 to 100 Hz and a digitisation sampling rate of 250 Hz.

Data analysis

Average ERPs, from −200 ms to 1000 ms after the presentation of the critical final verbs, were computed for each of the three types of sentences. Artefacts were automatically rejected by eliminating those epochs that exceeded +/− 65 μV and those with amplifier saturation artefacts. Approximately 4% of the trials were excluded for these reasons. Offline correction of smaller eye movement artefacts was made, using the method described by Semlitsch, Anderer, Schuster and Preelich (1986). For the entire sample of electrodes, originally M2-referenced data were re-referenced off-line using the average of the mastoids (M1 and M2) method. Averages were aligned to a −200 ms prestimulus baseline.

Overall repeated-measures analyses of variance (ANOVAs) were first performed with the purpose of performing amplitude comparisons between the ERP pattern elicited by word category errors, verb inflection violations, and correct sentences. Amplitude was measured as the mean amplitude of a particular time interval. To avoid a loss of statistical power when repeated-measures ANOVAs are used to quantify large number of electrodes (Oken & Chiappa, 1986), ten regions of interest were computed out of 58 electrodes, each containing the mean of five electrodes (see Figure 1). The regions were: Region 1: left parieto-occipital (P7, P5, P3, PO7, PO3); Region 2: right parieto-occipital (P8, P6, P4, PO8, PO4); Region 3: left central (T7, C5, C3, CP5, CP3); Region 4: right central (T8, C6, C4, CP6, CP4); Region 5: left frontal (F7, F5, F3, FC5, FC3); Region 6: right frontal (F8, F6, F4, FC4, FC2); Region 7: anterior frontal (Fp1, Fpz, Fp2, AF3, AF4); Region 8: central frontal (FC1, FCz, FC2, F1, F2); Region 9: central central (CP1, CPz, CP2, C1, C2); Region 10: central parieto-occipital (PO1, POz, PO2, P1, P2).

These ANOVAs included two within-subjects factors: sentence type (three levels: correct, word category violations, verb inflection violations) and region of interest (10 levels). The Geisser-Greenhouse correction was always applied. On a second step, further ANOVAs were performed for each particular region of interest with sentence type as a within-subjects factor (three levels: correct, word category violations, verb inflection violations). Finally, statistical post-hoc analyses comparing each sentence type were conducted for each particular region of interest whenever appropriate.

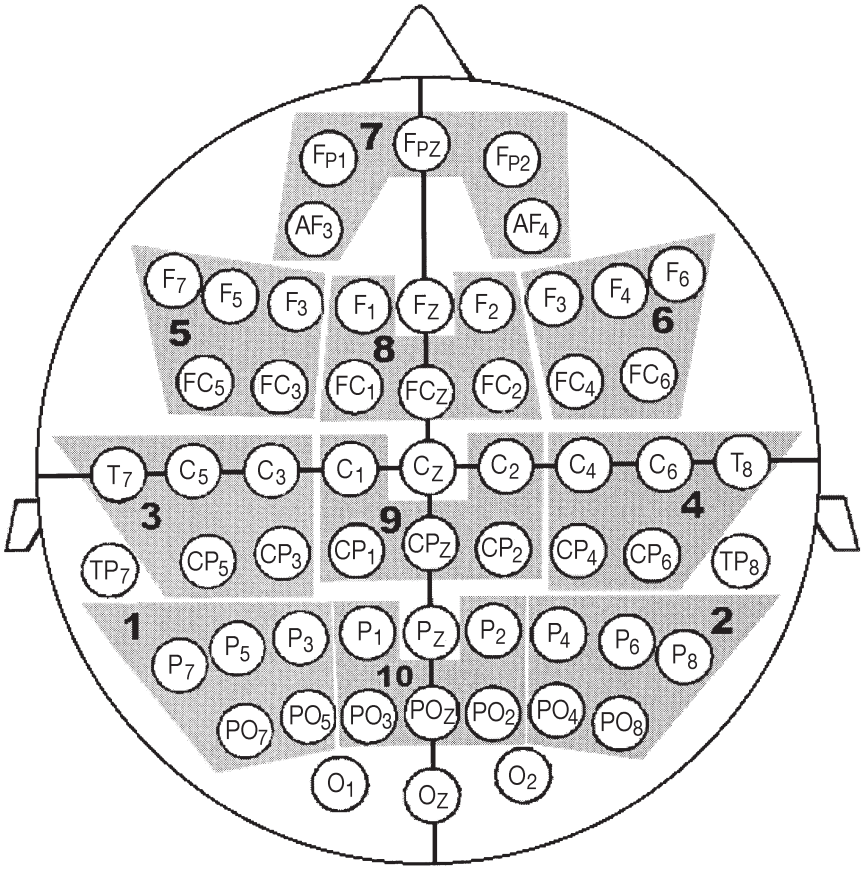

Figure 1. Layout of the 10 regions of interest in relation to the measured electrodes.

RESULTS

Behavioural data

The percentage of correct grammatical judgements was measured. On average, participants judged correctly 98% of the sentences (range 94%–100%). Overall, performance seems to be therefore excellent, indicating that subjects were attending to the experimental stimuli.

Electrophysiology

After a visual inspection of the grand-averaged ERPs, three main effects were noticeable as a result of the comparison between correct words and incorrect stimuli. The first of these components was a left frontal negativity

with an onset of about 250 ms. About the same time, a larger negativity for word category violations as compared with verb inflection violations and correct words can be observed at posterior sites. A third effect was a centroparietal positivity, which was more broadly distributed for word category errors as compared with verb inflection violations. This effect started to differ between correct and incorrect words about 450 ms and peaked around 550 ms after stimulus onset. The amplitude of the early

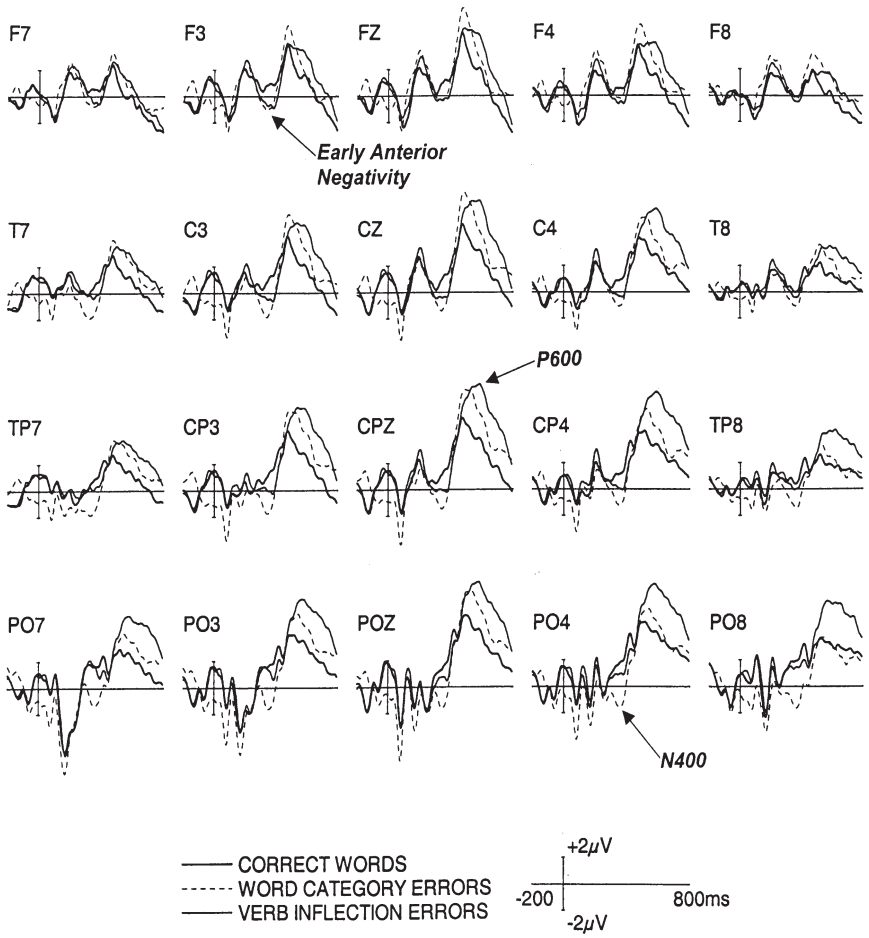

Figure 2. Grand-average ERP waveforms for the critical word of correct sentences, word category errors and verb inflection violations in a selected sample of electrodes. Data has been subjected to low-pass filtering at 20 Hz. An erly negativity and a late positivity can be identified for both error types. Also. an N400 can be observed, being maximal for word cateogory errors.

negativities was measured in the 250–400 ms time interval for statistical purposes. The centroparietal positivity, however, seemed to show a nonhomogeneous behaviour, so we decided to perform statistical analyses in two time intervals, 500–600 ms and 600–700 ms respectively. Figure 2 shows the waveforms corresponding to the final verb of sentences with word category errors, verb inflection errors, and correct sentences.

250–400 ms: The results of the overall ANOVA revealed a significant effect in the sentence type × region of interest interaction ($F18, 486 = 6.6; p \leq .0001$) at this time window. Separate ANOVAs for each particular region of interest reached significance at region 1, ($F2, 54 = 8.1; p \leq .002$); region 2, ($F2, 54 = 12.1; p \leq .0001$); region 3, ($F2, 54 = 6.6; p \leq .005$); region 5, ($F2, 54 = 3.6; p \leq .05$); region 8, ($F2, 54 = 5.6; p \leq .01$); and region 9, ($F2, 54 = 4.1; p \leq .04$). The ANOVA conducted at region 4, resulted in a statistical trend ($F2, 54 = 3.4; p = .054$). Finally, post-hoc analyses were conducted in those regions that showed significant results in these ANOVAs. These analyses compared sentences with word category errors vs. correct sentences, sentences with verb inflection errors vs. correct sentences, and sentences with word category errors vs. sentences with verb inflection errors. The results of these analyses are detailed in Table 2. Differences between incorrect and correct sentences were evident at left frontal electrodes (region 5) and centroparietal electrodes (region 9). However, sentences with word category errors and those with verb inflection violations did not differ at these electrodes. Differences were also noticeable at posterior electrodes (regions 1 and 2). At these regions, sentences with word category violations differed from both sentences with verb inflection violations and correct sentences, so the former type elicited

TABLE 2
Results of the statistical analysis comparing sentence types for each particular region of interest in the 250–400 ms time interval *F*(1,27)

	WCE vs. Correct		*VIE vs. Correct*		*WCE vs. VIE*	
Region	F	p	F	p	F	p
1 (left parieto-occipital)	16.35	.000***	n.s.		7.23	.012*
2 (right parieto-occipital)	17.44	.000***	n.s.		13.7	.001**
3 (left central)	11.4	.002**	3.76	.063^{+}	3.6	.069^{+}
4 (right central)	4.43	.045*	n.s.		n.s.	
5 (left frontal)	5.47	.027*	7.12	.013*	n.s.	
8 (central frontal)	n.s.		4.01	.022*	n.s.	
9 (central central)	5.6	.025*	5.87	.055^{+}	n.s.	

WCE, Word Category Errors; VIE, Verb Infection Errors; n.s., not significant; $^{+}$Statistical Trend; *$p < .05$; **$p < .005$; ***$p < .0001$.

a greater negativity than the latter two types. There were no differences between sentences with verb inflection violations and correct sentences at regions 1 and 2.

The inspection of the waveforms together with the statistical analyses conducted in this time window revealed the possible co-occurrence of negative responses at both anterior and posterior regions. In order to explore the scalp topography of these effects with the purpose of establishing whether these negativities are different effects or a similar component with an anterior-posterior distribution, we scaled data according to McCarthy and Wood (1985) procedure. An ANOVA was then performed on these data with sentence type (three levels), region of interest (six levels) and hemisphere (two levels) as within-subjects factors, which lead to significant results in the interaction of sentence type $\times$ region of interest, $F(4, 108) = 4.7; p \leq .02$, and sentence type $\times$ region of interest $\times$ hemisphere, $F(4, 108) = 9.1; p \leq .00001$. The interaction between sentence type and hemisphere reached a statistical trend, $F(2, 54) = 3.5; p = .054$. Thereafter, we conducted additional ANOVAs with scaled data at those particular regions of interest where anterior and posterior negativities were more evident in order to explore possible laterality effects (regions 5, 6 and regions 1, 2, respectively) with sentence type (three levels) as a within-subject factor. Results were significant at region 5, $F(2, 54) = 5.5; p \leq .02$, but not at region 6, which indicates that the anterior negative effect is present only at left frontal electrodes. In the case of the posterior negativities, statistical differences were noticeable at both region 1, $F(2, 54) = 14.3; p \leq .0001$ and region 2, $F(2, 54) = 17.4; p \leq .0001$, which indicates a lack of lateralization for these effects. Altogether, these findings indicate that the anterior negativity and the posterior negativity are in fact different components with different scalp distributions.

500-600 ms: The ANOVA showed significant effects of the interaction between sentence type $\times$ region of interest, $F(18, 486) = 3.2; p \leq .02$, at this time window. Separate ANOVAs for each region of interest showed significant results at all regions of interest, $F(2, 54) = 3.6 - 12.6; p \leq .05$. The results of additional post-hoc comparisons are summarised in Table 3. Differences between the two types of incorrect sentences and correct sentences were evident all over the scalp. The strongest effects were observed at centroparietal and left central electrodes (regions 9, 10, and 3). There were no differences between sentences with word category violations and those with verb inflection violations (except at region 2).

600-700 ms: The ANOVA yieled significant results in the sentence type $\times$ region of interest interaction, $F(18, 486) = 5.6; p \leq .002$, at this time

TABLE 3
Results of the statistical analysis comparing sentence types for each particular region of interest in the time window between 500 and 600 ms *F*(1,27)

	WCE vs. Correct		*VIE vs. Correct*		*WCE vs. VIE*	
Region	F	p	F	p	F	p
1 (left parieto-occipital)	7.56	.01*	20.06	.000***	3.44	.075^{+}
2 (right parieto-occipital)	n.s		17.32	.000***	13.52	.001**
3 (left central)	11.65	.002**	23.34	.000***	n.s.	
4 (right central)	7.72	.01*	17.59	.000***	3.66	.067^{+}
5 (left frontal)	4.07	.054^{+}	13.91	.001**	n.s.	
6 (right frontal)	8.57	.0007*	11.23	.002**	n.s.	
7 (anterior frontal)	5.98	.021*	4.62	.041*	n.s.	
8 (central frontal)	7.41	.011*	21.06	.001**	n.s.	
9 (central central)	10.99	.003**	21.52	.000***	n.s.	
10 (central parieto-occipital)	9.4	.005*	15.08	.000***	n.s.	

WCE, Word Category Errors; VIE, Verb Infection Errors; n.s., not significant; $^{+}$Statistical Trend; *$p < .05$; **$p < .005$; ***$p < .0001$.

window. Separate ANOVAs for each particular region of interest reached significance in all regions, $F(2, 54) = 3.7 - 24.6, p \leq .04$, with the exception of region 7 that only reached a statistical trend, $F(2, 54) = 2.7$, $p = 0.85$. Finally, the results of post-hoc analyses at each particular region of interest are shown in Table 3. Sentences with verb inflection violations differed from both sentences with word category violations and correct sentences in most of the scalp locations. In this regard, sentences with verb inflection errors elicited a greater positivity as compared with the other sentence types. These differences were especially evident at right central and right parieto-occipital electrodes (regions 2 and 4). Differences between sentences with word category violations and correct sentences were still observed at centroparietal and left parieto-occipital electrodes (regions 1, 3, and 9).

DISCUSSION

A first aim of the present study was to investigate whether phrase structure and verb inflection anomalies in Spanish elicit a similar ERP pattern to that reported in studies with other languages. A second objective concerned the comparison of the ERP responses evoked by phrase structure violations and morphosyntactic anomalies. The results of this experiment revealed that both types of violations in Spanish evoked early negativities and late positivities which are very similar to those reported in English, Dutch, or German languages. With respect to the second objective, although no differences in anterior electrodes were observed

TABLE 4
Results of the statistical analysis comparing sentence types for each particular region of interest in the 600–700 ms time interval $F(1,27)$

	WCE vs. Correct		*VIE vs. Correct*		*WCE vs. VIE*	
Region	F	p	F	p	F	p
1 (left parieto-occipital)	6.59	.016*	40.21	.000***	9.44	.005*
2 (right parieto-occipital)	n.s		39.44	.000***	32.77	.000***
3 (left central)	6.78	.015*	22.76	.000***	6.27	.019*
4 (right central)	n.s.		32.54	.000***	24.63	.000***
5 (left frontal)	n.s.		8.17	.008*	3.63	.067^{+}
6 (right frontal)	n.s.		15	.001**	6.14	.02*
7 (anterior frontal)	4.69	.039*	4.7	.039*	n.s.	
8 (central frontal)	n.s.		12.34	.001**	5.74	.004**
9 (central central)	4.56	.042*	28.77	.000***	10.87	.003**
10 (central parieto-occipital)	5.02	.034*	38.17	.000***	9.91	.024*

WCE, Word Category Errors; VIE, Verb Infection Errors; n.s., not significant; $^{+}$Statistical Trend; *$p < .05$; **$p < .005$; ***$p < .0001$.

between sentences with word category and those with verb inflection violations in an early time window, differences at this latency were nevertheless noticeable at posterior sites. At these electrodes, word category violations elicited a greater negativity as compared with verb inflection violations and correct words. During subsequent time intervals both similarities and divergences arose in the comparison of the different violation types as will be discussed below. Overall, it seems that syntactic and morphosyntactic processing have some features in common but have also some particularities. The results concerning early anterior and posterior negativities and late centroparietal positivities will be separately discussed now.

Early negativities

Our results show that both word category and verb inflection violations, elicited a similar negativity at left frontal electrodes starting at similar latencies, not evoked by words in correct sentences, in the 250–400 ms time interval. Similar findings have been previously reported for both types of anomalies in several studies (for word category violations, Friederici, Pfeifer, & Hahne, 1993; Gunter et al., 1999; Neville et al., 1991 ; for verb inflection violations, Hagoort & Brown, 2000b; Penke et al., 1997; Weyerts et al., 1997). Moreover, this is the first time that early anterior negativities are reported for word category and verb inflection violations in Spanish. Accordingly, the present and Demestre et al. (1999) study on gender agreement violations with auditory presentations constitute the starting point of a growing body of evidence showing that a variety of syntactic

anomalies elicit early anterior negativities in Spanish similar to those reported in English, German, or Dutch.

This is also the first time, to our knowledge, that early negativities elicited by verb inflection and word category anomalies are reported in the same study and become, therefore, directly comparable. In this regard, and from a functional perspective, our data suggest that morphosyntactic violations, such as verb inflection anomalies, disrupt the building of first-pass parsing analyses in a similar way to word category errors. According to some psycholinguistics models (Frazier, 1990; Frazier & Rayner, 1982) differences could be expected between word category and verb inflection violations during early parsing processes. According to such approaches, word category information is essential for phrase structure building and is postulated to be processed earlier in time than morphosyntactic information concerning violations of verb inflection properties. In support of this view, several ERP studies reported very early anterior negativities for phrase structure violations (Friederici et al., 1993; Gunter et al., 1997, 1999). However, other studies reported early anterior negativities for word category violations displaying onsets comparable to those elicited by morphosyntactic violations (Friederici et al., 1996; Kutas & Hillyard, 1983). Our data, where a direct comparison has been feasible, would be in consonance with the latter group of studies.

At least three studies are of particular interest because they included both word category and morphosyntactic violations in their experimental designs. As mentioned in the introduction, two of these studies failed to report early anterior negativities for either word category or verb inflection violations (Gunter, & Friederici, 1999; Hagoort et al., 1993). In the third of these studies, Hagoort and Brown (2000b) included sentences with word category errors, subcategorisation violations and verb inflection violations (noun-verb number agreement violations) that were presented in auditory and visual modalities. These authors found no early negative effects to word category violations in either modality of presentation. Verb inflection violations resulted in an early anterior negativity only in the auditory modality of stimulation. These authors concluded from these somewhat negative findings that the pattern of results they found is at odds with the claim of some authors about the pre-eminence of word category information during early syntactic analyses. Our results would add direct support to the Hagoort and Brown point of view.

By contrast, the results of the present study disagree with the findings reported in the Hagoort et al., (1993) and Gunter and Friederici (1999) works. These studies did not find early anterior negativities for either phrase structure or morphosyntactic violations. A careful inspection of the materials reveals the existence of some differences between the materials presented in these studies and those used in our study. In this regard,

Hagoort et al. (1993) presented sentences including subject-verb number disagreement instead of verb inflection violations. Moreover, this violation occurred in two consecutive words whereas there were several intervening words between the subject and the verb inflectional violations in our study. Finally, phrase structure errors and morphosyntactic violations were not presented in different versions of the same sentences, but in totally different sentences. By contrast, the two violation types were presented in different versions of the same sentences in the present study, which allows a more direct comparison. In the case of the experiment by Gunter and Friederici (1999), its design resembles to some extent the one used in our study. However, there is an important difference between the materials presented in both studies. In this regard, Gunter and Friederici (1999) presented what they called an 'across category substitution' (they replaced a past participle form by an inflected verb form). By contrast, we presented what these authors called a 'within category substitution' (realised by replacing the third person by the first person of an inflected verb). As these authors acknowledge, the two kinds of substitutions should have different consequences for syntactic analyses. Overall, it seems that at the present state of knowledge it is difficult to provide solid reasons for the discrepant pattern of results apart from methodological ones. Instead, more efforts are needed in order to design experiments that can further elucidate this question.

Two concerns should also be mentioned here. First, verb inflection violations occurred in our experiment in the main clause on the sentences whereas word category violations occurred in the subordinate clause. This means that verb inflection errors occurred in a clause that is higher in hierarchy in the syntactic tree than the subordinate clause where word category anomalies occurred. This could have resulted in an enhancement of the early anterior negativity to verb inflection violations, which might have equated it to the effects elicited by word category errors. However, this cannot be the case since the results of some studies suggest that violations that occur within embedded clauses are indeed more difficult to process than those occurring in the main clause. This was reflected by an enhancement of early anterior negative effects for morphosyntactic violations occurring in the embedded subordinate clause as compared with anomalies occurring in the main clause (Vos et al., 2001a).

Second, whereas in our experiment word category anomalies could be processed by detecting a mismatch between immediately adjacent elements, a subordinate clause was embedded between the subject of the main clause and the location where the verb inflection violation occurred. Although the subordinate clause in our experiment had only four words, working memory demands seem to be therefore higher in the case of the processing of verb inflection violations as compared with word category

anomalies in our experiment. According to some views this could result in an enhancement of the early anterior negativity to verb inflection violations (King & Kutas, 1995; Kluender & Kutas, 1993; Vos et al., 2001a). Of particular interest are, however, the results of an investigation by Gunter et al., (1997), since part of their experimental conditions resemble those used in our experiment in several aspects. Gunter and collaborators presented their subjects with a condition of high working memory load in which a subordinate clause was embedded between the subject of the main clause and its incorrectly conjugated predicate, just as in our condition of verb inflection errors. By contrast, in the condition of low working memory load, the violation occurred at adjacent words. Despite these differences, incorrect conjugated verbs elicited an early anterior negativity of a comparable magnitude in the conditions of both high and low working memory loads. This pattern of results suggest that working memory load, as defined in the studies by Gunter and collaborators and ours, would not affect verb inflection violations.

Accordingly, it seems that, at least under certain circumstances, verb inflection violations elicit similar early anterior negativity effects to those elicited by word category violations. This means that under these circumstances the processor can access information concerning verb inflection properties and word category in a similar manner during early syntactic processing, which minimises the importance that some theoretical perspectives attach to information about word category.

We will turn now to the discussion of the differences found at posterior locations between 250 and 400 ms after the onset of the critical word. In this time interval the two types of incorrect sentences elicited equally larger negativities as compared with correct sentences at centroparietal electrodes. Also, at bilateral parietal locations word category violations elicited larger negativities as compared with both verb inflection violations and correct words. The results of the profile analyses confirmed that the posterior negativity is qualitatively different from the anterior negativity found in the present experiment. This posterior negativity is likely to be related to the N400 component, a response that is highly sensitive to semantic manipulations as reported in several studies (Federmeier & Kutas, 1999; Hagoort, & Brown, 2000a; Koivisto & Revonsuo, 2001; van den Brink, Brown & Hagoort, 2001; West & Holcomb, 2002). The most accepted view about the functional significance of this component is that it reflects semantic integration processes (Kutas & Federmeier, 2000; Kutas, Federmeier, Coulson, King, & Münte, 2000). Although the presence of N400 effects elicited by syntactic violations is not a common finding in the literature, several experiments found similar results to those reported here. In this regard, Osterhout and Holcomb (1992) reported N400 effects elicited by phrase structure violations. Hagoort et al. (1993) found N400

effects elicited by the final word of sentences with either phrase structure violations or subject-verb number disagreement. Gunter & Friederici (1999) reported larger N400 amplitudes for word category violations as compared to verb inflection violations. Finally, Gunter et al., (2000) found N400 responses elicited by a gender mismatch between an article and a noun.

It should be noticed that not all syntactic anomalies disrupt semantic processing in a similar manner. Hagoort et al., (1993) have suggested that phrase structure violations are 'less easily reinterpreted semantically in comparison to the agreement violation, which does not seriously affect the way in which the content words in the sentences are ordered and combined into a coherent interpretation of the sentence' (p. 445). This claim is supported by the results of the Gunter and Friederici (1999) study mentioned above (larger N400 for word category violations compared with verb inflection errors). In the particular case of the present experiment, the verb inflection violation is realised by an incorrect suffix on the verb, which does not seriously affect the semantic relations between words in the sentences. By contrast, word category anomalies appear to be less easily reinterpreted semantically in comparison with verb inflection violations. In our experiment, word category violations were realised by removing the noun in the object relative clauses, which obviously disrupts the integration of sentence elements into a coherent semantic representation. Therefore, differences observed at centroparietal locations in the present study during the 250–400 ms period of time, might reflect the greatest difficulties with semantic integration processing in incorrect sentences as compared with correct ones, these difficulties being more noticeable in the case of word category violations. Also, the co-occurrence of an anterior negativity, that reflects syntactic processing, with N400 effects, that reflect semantic analyses, have some implications for models of language processing. In this regard, our data suggest that during initial stages of comprehension, semantic and syntactic information is processed in parallel rather than sequentially. Similar conclusions were reached by Gunter et al. (1997) and Gunter et al. (2000) who also reported the co-occurrence of anterior and posterior early negativities for verb inflection violations and article-noun gender disagreement, respectively.

As a final remark, we should note that the use of the sentence-final words as the critical words has some implications for semantic and sentence wrap-up analyses of syntactic anomalies. Some authors have suggested that ERP effects of the local violations and the more global effects of sentence processing tend to overlap more strongly in sentence-final positions (Hagoort et al., 1999). The results of some studies show that in sentences that subjects judge as unacceptable, final words elicit an enhanced N400 response, regardless of whether the unacceptability is

semantic or syntactic (Osterhout & Holcomb, 1992; Hagoort et al., 1993). For instance, Osterhout and Holcomb (1992) found that phrase structure violations elicited N400 effects when words were presented as final words of unacceptable sentences but not when they were embedded within sentences. However, this is not a uniform pattern of results and some studies including phrase structure violations at final-sentence positions failed to report N400 effects at all (Friederici, Steinhauer, & Frisch, 1999; Gunter et al., 1999, Hahne & Friederici, 1999; Hahne and Jescheniak, 2001). In the particular case of our experiment, the presence of the anomalies in final-sentence words could have greater implications for word category anomalies than for verb inflection violations resulting in an enhanced N400 response for the former anomaly type. This finding could be taken to reflect that word category anomalies have worse consequences for sentence wrap-up and closure effects than verb inflection violations, probably due to the absence of the subject of the main clause in the sentences with word category errors. In whatever case, in the present experiment it is difficult to disentangle whether the N400 effects are attributable to the effects of the local violation or to global sentence processing effects, so some caution is needed with regard to this possibility.

Late positivities

The results of the present experiment showed that both phrase structure and verb inflection violations elicited a positivity around 600 ms that was widely distributed. Similar effects have been previously reported in several investigations (Coulson et al., 1998; Gunter et al., 2000; Hagoort & Brown, 2000b; Rodriguez-Fornells et al., 2001), although a few studies failed to observe P600 effects to verb inflection violations (Penke et al, 1997; Weyerts et al, 1997). P600-like effects have been previously reported in Spanish to noun-adjective gender agreement violations (Demestre et al., 1999). Therefore P600 seems to be a reliable effect not only in English, German, or Dutch, but also in Spanish.

A further inspection of our data revealed that word category violations and verb inflection errors not only share but also differ in some aspects by the time that P600 effects arise. Whereas word category and verb inflection anomalies elicited similar effects between 500 and 600 ms after stimulus onset, clear differences emerged between both types of violations in the 600–700 ms period of time. Also, the P600 elicited by word category violations was more broadly distributed than the P600 evoked by verb inflection anomalies. The results of an experiment by Friederici, Mecklinger, Spencer, Steinhauer, and Donchin (2001) could account for this pattern of divergences. Friederici and collaborators investigated the processing of temporally ambiguous subject-first and object-first sentences

containing relative and complement clauses. As these authors pointed out, there is a strong tendency to disambiguate subject and object sentences towards a subject first reading in German. In addition, revision processes were assumed to be easier for relative clauses than for complement clauses on the basis of structural linguistic considerations. Several ERP effects differentiated between sentence types at posterior regions during the 400–900 ms time interval that were related to the P600 component. Specifically, an early effect between 400 and 600 ms discriminated object from subject sentences in general. In this regard, subject sentences showed an earlier latency than object sentences. Friederici and collaborators interpreted this effect as the reflect of a diagnosis mechanism that evaluates the structure of the sentences. During a subsequent time interval, 600–900 ms, an effect was only present for the complement clauses. This effect was associated with processing costs reflecting the computation of a new syntactic structure when deriving object from subject complements. Overall, Friederici and collaborators concluded that the P600 seems to reflect different subprocesses at varying time points. Similar conclusions were previously outlined by other researchers (Hagoort & Brown, 2000b; Münte et al., 1998).

Results from our experiment could be interpreted on the basis of Friderici and collaborators' conclusions. In this regard, both word category and verb inflection violations elicited in our experiment a very similar P600 effect in the first (500–600 ms) time range. This effect could be therefore attributed to a reanalysis/diagnosis mechanism that establishes the inappropriateness of the syntactic structure in sentences including either word category or verb inflection violations, triggering repair processes. Later in time, however, differences arose between word category and verb inflection violations (600–700 ms time interval), which were more evident at right central and right parieto-occipital electrodes, although spread all over the scalp. Verb inflection violations still evoked a robust P600 effect whereas word category violations elicited a smaller effect that is even comparable in size to the effect elicited by correct sentences at some scalp regions. A possible explanation for this reduction of the effects evoked by word category violations concerns the impossibility of repairing the syntactic structure of these sentences. However, such a repair process is still likely to be performed in the case of verb inflection violations since these error types do not disturb the syntactic structure of a sentence to the same extent than word category violations do. It should be reminded at this point that the difference between correct and incorrect inflected verbs was only evident in the suffixes, that is, the last part of the verbs. Therefore, it seems that when the sentence ending has the potential of making sense, there is more incentive to find a suitable syntactic structure. Thus, the prolonged P600 for verb inflection violations effect would reflect

the additional costs of the attempt of reprocessing, as suggested by several authors (Kaan et al., 2000; Friederici et al., 2001).

An alternative or even complementary explanation for the different pattern of P600 effects could also be made, again, in terms of working memory processes. The distance that exists between the subject and the location where the verb inflection violation occurs, which contrasts with the mismatch between immediately adjacent elements in the word category violation condition, might imply differences in working memory requirements, which, in turn, would explain differences in P600 effects. The results of previous studies revealed, however, that high demands in working memory delayed the P600 latency (Friederici, 1997; Mecklinger et al., 1995; Münte et al., 1997; Vos et al., 2001a; Vos, Gunter, Schriefers, & Friederici, 2001b). The only study that found modulations in the P600 amplitude as a consequence of working memory demands was one by Gunter et al. (1997). In that experiment, larger P600 amplitudes were evoked in the condition of low working memory (verb inflection violation occurring in two adjacent words), as compared with the condition of high working memory (subordinate clauses were embedded between the noun and the verb inflection error). These findings contrast our observation of larger P600 effects when the verb inflection violation occurs in non-adjacent words as compared with adjacent words. Accordingly, as was the case for early anterior negativities, a clear relation could not be established between the processes indexed by P600 and working memory constraints.

The fact that verb inflection violations occurred in the main clause whereas word category violations occurred in the relative clause should be again noted. The only previous study that investigated this question reported no differences in either the amplitude or the latency of the P600 between violations occurring in one of the main clauses of sentences with a conjoined structure, and those occurring in a subordinate clause (Vos et al., 2001a). Therefore, it seems that this variable has little impact in those processes reflected by the P600.

A final aspect refers to the relation between N400 and P600. Specifically, we could not totally rule out the possibility that the large N400 component for word category violations could result in a diminished P600 as a consequence of the overlapping of both components and their underlying processes as suggested by some researchers (Hagoort et al., 1993). In this regard, Gunter et al. (2000) reported reduced P600 effects as the difficulty of performing semantic analyses, reflected by an enhanced N400 response, increases. These authors argued that this fact could reflect a strategy of the comprehension system to focus on meaning. In keeping with Gunter and co-workers' findings, our data show that phrase structure violations elicited a larger N400 component followed by a diminished P600 response as compared with verb inflection errors. This pattern of results also suggest

the possibility that encountering a severe disruption of semantic analyses makes any further attempt of repairing the structure of the sentences unapproachable, which results in a diminished P600 effect, since semantic information is not totally available. By contrast, verb inflection violations impose less severe problems to the semantic analyser, so the attempt of repairing sentence structure is more likely to be initiated. In any case, in the light of Gunter and collaborators' findings and our results, it seems likely that the degree of semantic coherence has strong implications for later reanalysis and repairing processes, although the precise status of this relationship needs further investigation.

Conclusion

The first conclusion of this study refers to the finding of an ERP pattern elicited by phrase structure and morphosyntactic violations in Spanish which is comparable to the findings reported in other languages. This argues in favour of the existence of similar brain mechanisms involved in syntactic processing across different languages.

A second aspect concerns the comparison between the processing of different types of syntactic information, that is word category and verb inflection information. Overall, our data suggest that, at least under some circumstances, verb inflection and phrase structure violations can trigger very similar processes during early steps of syntactic processing. Divergences are more likely to be semantically related, as the presence of N400 effects at posterior electrodes elicited by word category violations but not by verb inflection violations seems to suggest. Reanalysis processes that occur during later syntactic processing seem to be triggered in a similar manner by the two violation types. In addition to these similarities, however, some differences also arise during final stages of syntactic analyses between phrase structure and morphosyntactic anomalies. Such differences might be related to a failure when attempting to repair the syntactic structure when a word category violation occurs.

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