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Research report

Event-related potentials elicited during parsing of ambiguous relative clauses in Spanish

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Abstract

Previous behavioural studies in Spanish have found a significant preference for attaching relative clauses preceded by a complex NP (N1 of N2 RC) to the first noun phrase. In the present study, we used event-related potentials (ERPs) to help identify the nature of these processes by directly comparing ERPs to temporary ambiguous sentences containing relative clauses that were finally consistent with either high or low attachment resolution. The larger amplitude of the P600 effect for the low attachment condition suggests that high attachment was the preferred strategy. The P600 effect was widely distributed in the 500–700 ms window, including frontal areas, while the distribution was mainly posterior in the 700–1000 ms window. The results indicate that high attachment is the parsing strategy Spanish readers use for this type of ambiguity and suggest that the P600 may not be a monolithic effect.

Theme: Neural basis of behaviour
Topic: Cognition

Keywords: Parsing; ERP; P600; Sentence processing; Relative clauses; Attachment

Language comprehension involves combining words we hear or read in a particular way to extract meaning. When reading or listening to sentences, we use syntactic information, among other types of information, to determine the meaning of a sentence ('Who did what to whom?'). Syntactic processes in sentence comprehension include combining words into larger units such as phrases and clauses on the basis of word category information and grammar rules to build a structure. Checking agreement is another important part of this enterprise of attaching constituents within the sentences, especially in Romance languages. In Spanish, for instance, the verb needs to agree in number and person with the subject and agreement of gender and number is necessary between pronouns and antecedents, adjectives, determiners and nouns, etc. To illustrate the importance of combining constituents and of checking agreement in comprehension, a phrase such as (1a) means something very different from a phrase such as (1b)

(1a) El criado de la actriz que estaba divorciado [*The servant (masc) of the actress (fem) who was divorced (masc)*]
(1b) El criado de la actriz que estaba divorciada [*The servant (masc) of the actress (fem) who was divorced (fem)*]

These two sentences are unambiguous because of the gender agreement between "divorciado/a" and one of the antecedents. However, these sentences are temporarily ambiguous from the beginning of the relative clause "que" up to the moment in which the gender of "divorciado/a" is processed.

Over the last 10 years or so, there has been a vast amount of behavioural research into attachment preferences in different languages with sentences containing a relative clause preceded by a complex NP with two possible hosts such as (1a) and (1b), following the seminal paper by Cuetos and Mitchell [7]. On-line data have indicated that

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while English readers show either no preference [4,28] or low attachment preference [i.e., "who was divorced" was read faster in (1b) than in (1a)][1] [5], Spanish readers show high attachment [i.e., "who was divorced" was read faster in (1a) than in (1b)] [3,4,5,7; but see Ref. 12]. On-line preferences for low attachment preferences have also been reported in Italian [10,11; but cf. Ref. 17], but high attachment has been found in other languages such as French, German and Dutch [2,27,41].

Several hypotheses have been advanced to explain the cross-linguistic differences of attachment preferences with sentences containing a relative clause preceded by a complex NP with two possible hosts, though none of these are completely satisfactory. On the one hand, it has been suggested that high attachment could be the result of extrasyntactic factors. Low attachment as the expression of a universal processing principle such as Late Closure could be initially pursued, but later changed into a high attachment preference [15]. According to the Construal hypothesis, late closure would be restricted to "primary phrases" [16]; therefore, the high attachment preference observed in Spanish in the case of modifiers (one kind of "nonprimary phrase") could be attributed to a discourse-based preference. On the other hand, it has been claimed that the high attachment preference is determined by the frequencies with which alternative disambiguations have been previously encountered, according to the Tuning hypothesis [8]; to the relative weights of two parameters with opposite forces: predicate proximity (attach to the head of the predicate) and recency (attach to the most recent site), according to the Predicate Proximity and Recency hypotheses [22]; or to the cross-linguistic differences of the prosodic weight size of constituents that would influence preferences for attaching the RC to the complex NP or to the second host of the complex NP [13].

These hypotheses invoke mechanisms of different nature to account for the behavioural data, but none of them are completely satisfactory. The on-line behavioural data—moving window and eye movements—do not allow us to discriminate the nature of the information involved in the attachment of the RC to one of the noun phrases, as increases of reading times, first pass times, total times or number of regressions in the eye tracking data occur following an anomaly at any linguistic level. In contrast, syntactic and semantic anomalies elicit different ERP effects (see [Ref. 26], for an overview). Semantic anomalies and difficulties in semantic integration elicit a negative wave with a broadly parietotemporal distribution that peaks at about 400 ms after the anomalous word appears (the *N400 effect*) [31–33]. Syntactic processing, however, has been associated with two separate ERP components. A *left anterior negativity* has been elicited by syntactic (e.g., phrase structure, subcategorizacion) and morphosyntactic (e.g., subject–verb, article–noun and antecedent–pronoun agreement) violations. This component has an anterior distribution, starting as early as 250 ms, and larger amplitude in the left hemisphere [1,6,18,35]. The second component associated with syntactic anomalies and nonpreferred syntactic structures is a large positive wave that onsets at about 500 ms after presentation of the anomalous word and persists for at least 500 ms (the *P600 effect*/syntactic positive shift) [1,25,29,30,37,38]. In particular, the P600 or syntactic positive shift (SPS) has been related to the processes of revision and repair in sentence processing.

It appears that these two syntax-related components (LAN and P600/SPS) are different from the semantics-related N400 component in timing, scalp distribution and eliciting stimuli, and that LAN is elicited only after certain types of violations, while the P600 is elicited by syntactically ambiguous structures without ungrammaticality. While it is far from clear that this knowledge about the eliciting conditions of certain ERP effects will allow us to draw a line between the competing theories, it will certainly help to advance our empirical knowledge and to evaluate the strengths of the proposals, if not to discard the empirical plausibility of some of these.

The present experiment has two goals. The first was to investigate whether the previous behavioural results of high attachment preference obtained in Spanish [3–5,7] could be traced through electrophysiological correlates. This is important as it will provide further empirical evidence regarding the attachment preferences of Spanish readers with this type of ambiguities and will shed more light on the nature of the process involved, further advancing our knowledge of cross-linguistic parsing strategies. To that end, we used sentences such as (1a) and (1b) that are ambiguous up to the critical adjective since the relative clause can modify either NP. Behavioural studies have shown that native Spanish readers prefer to have a relative clause modify the first NP [3–5,7]. The adjective in the preferred condition agrees in gender with the first NP and hence confirms this interpretation. The adjective in the nonpreferred condition agrees only with the last NP and is therefore not compatible with the preferred analysis and should trigger revision or reanalysis. According to previous empirical evidence that contrasted preferred and nonpreferred structures [29], a P600 should be expected. A LAN effect is unlikely since this component only occurs to major primary syntactic violations, and the present structures do not even imply violations. However, an N400 effect could also be expected, taking into account previous results obtained by Schmitt et al. [39] and by Deutsch and Bentin [9] that analyzed the role of semantic and syntactic information during agreement processing by comparing grammatical and semantic gender processing. Schmitt et al. assessed gender agreement during

[1] To investigate this attachment ambiguity in English, we had to use sentences with pragmatic disambiguation such as "The police arrested the brother of the nursemaid who recently gave birth to twins in the hospital" (low attachment) vs. "The police arrested the sister of the handyman who recently gave birth to twins in the hospital" (high attachment) [4,5], while others [12] have used number disambiguation.

personal pronoun processing in German. They reported N400 and P600 effects in response to the agreement violation between a pronoun and its animate antecedent (semantic gender). Deutsch and Bentin investigated subject–predicate gender agreement in Hebrew, manipulating whether the subject was an animate or an inanimate noun, and whether this noun was morphologically overtly marked or unmarked (e.g., the woman saw that the boy/diamond$_{masc}$ had fallen$_{masc/femn}$ into the pond). An N400 effect was found after gender agreement violation only for the animate condition (semantic gender), and this effect did not interact with markedness. In addition, the violation of either semantic or grammatical gender agreement resulted in a P600 effect, but this effect interacted with the markedness as it was only significant for masculine-plural-marked predicates; that is, only marked forms elicited the P600 effect. In the present experiment, only animate morphologically marked antecedents were used. Hence, taking into account these previous results in German and Hebrew, besides a P600 effect, an N400 effect could also be predicted.

The second goal was to examine the electrophysiological patterns related to attachment ambiguity when there is not a strictly syntactic violation, but the parser chooses between a preferred and a nonpreferred attachment. There has been some debate about whether the P600 endorses several effects that could correspond to diagnosis and reanalysis processes or just complexity and that could result in different spatial distributions and/or different time windows (e.g., [Refs,21, 24,29]). Hagoort et al. [24,26] indicated that repair processes produce a late (700–900) more posterior distributed P600 effect, while revision processes produce an earlier (500–700) frontal/broad distributed P600 effect. However, Friederici et al. [18,21] and Kaan et al. [29,30] have indicated that ambiguity resolution and/or complexity produce a frontal/broad distributed P600 effect, while revision and repair processes produce a more posterior distributed effect. The present experiment will add further evidence to clarify what cognitive operations are influencing the different components of the P600 effect. No complexity is manipulated, only preference attachment differences. To explore ERP components related to preferential attachment in Spanish, the syntactic preference is evaluated by the gender agreement of the RC with one of its two possible hosts, one of the two noun phrases. Thus, according to Hagoort et al.'s proposal, a frontal/broad distributed P600 effect should be obtained, but according to Friederici et al.'s and Kaan et al.'s proposal, a posterior distributed P600 effect should be expected.

1. Method

1.1. Participants

Thirty undergraduate students, 24 females and 6 males, participated in the experiment in exchange for course credit. All were native Spanish speakers, with no history of neurological or psychiatric impairment and with normal or corrected-to-normal vision. Ages ranged from 18 to 38 years (mean = 19.37 years). All participants were right-handed, as assessed by an abridged Spanish version of the Edinburgh Handedness Inventory [36]. Data of three participants were rejected before the analysis because of too many artifacts in the EEG record.

1.2. Stimuli

One hundred and twenty experimental sentences similar to those used by Carreiras and Clifton [4,5], which contained a complex NP (N1 of N2) followed by an RC, were adapted, so that all sentences contained between 13 and 15 words. An example of the experimental sentences appears in Table 1.

The RC attachment to either N1 (high attachment) or to N2 (low attachment) was disambiguated by gender information. In half of the sentences, the interpretation of the sentences was compatible only with high attachment of the RC to the N1 and, in the other half, only with low attachment to the N2. In addition, the content of the RC required a feminine host for half the sentences and a masculine host for the other half.

In addition, a list of 80 filler sentences of different syntactic structures was generated to divert the attention of the subjects. Questions were asked in 30 experimental items and in 20 fillers to be sure that subjects were attending to the sentences and engaged in reading for comprehension. In total, each subject received 200 sentences without any type of syntactic violation. It is unlikely that subjects developed specific strategies to solve the attachment of relative clauses since 40% of the total number of sentences were fillers of different syntactic structures. Moreover, subjects were questioned at the end of the experiment about whether they had used any particular type of strategy to comprehend the sentences and did not report any.

1.3. Procedure

Participants were seated comfortably in a darkened sound-attenuated chamber. All stimuli were presented on a high-

Table 1
Sample sentences used in the Experiment 1

N1 host (high attachment)
Juan felicitó a la cocinera del alcalde que fue **premiada** y laureada en las fiestas.
John congratulated the cook (fem.) of the major (masc.) who was awarded a prize (fem) and honoured at the party.
N2 host (low attachment)
Juan felicitó al cocinero de la alcaldesa que fue **premiada** y laureada en las fiestas.
John congratulated the cook (masc.) of the major (fem.) who was awarded a prize (fem) and honoured at the party.

The **boldfaced** word was the critical disambiguating word.

resolution computer that was positioned at eye level 80–90 cm in front of the participant. The words were displayed in black lower-case letters against a grey background.

Participants were asked to read the sentences attentively since after some items, they would be questioned to assess comprehension. A response button was positioned beneath each thumb. For half of the participants, the right button was used to signal the "Yes" response and left button was assigned the "NO" response. For the remaining subjects, the order was reversed. Thus, the assignment of buttons to hands was counterbalanced across participants.

The sequence of events in each trial was as follows. First, a fixation point ("+") appeared in the centre of the screen and remained there for 300 ms. This fixation point was followed by a blank screen interval of 300 ms, then the sentence was displayed word by word. Each word appeared for 350 ms and was followed by a 350-ms blank interval. When participants were not prompted to respond, the next trial appeared after a variable interval between 500 and 1500 ms. If subjects were prompted to respond, the question mark "?" was presented for 300 ms and after 300-ms blank, a question with two possible answers appeared on the screen and remained there up to a maximum of 2000 ms or until the participant's response. After a variable interval of 500–1000 ms, the next trial started. All sentences were presented in a different random order for each participant, with two breaks of 5–10 min during which participants could rest and the impedances were checked.

Five warm-up sentences were provided at the beginning of the session and were repeated if necessary. Participants were also asked to avoid eye movements and blinks during the interval when the fixation asterisk was not present and they were directed to favor accuracy over speed in their responses. Each session lasted approximately 1 1/2 h.

1.4. EEG recording

Scalp voltages were collected from Ag/AgCl electrodes using a 128-channel Geodesic Sensor Net. Fig. 1 shows the schematic distribution of the recording sites. The vertex electrode was used as reference, and the recording was re-referenced off-line to linked mastoids. Eye movements and blinks were monitored with supra- and infraorbital electrodes and with electrodes in the external canthi. Interelectrode impedances were kept below 30 kΩ (amplifiers input impedance >200 MΩ). EEG was filtered with an analogue band-pass filter of 0.01–100 Hz (50-Hz notch filter), and a digital 35-Hz low-pass filter was applied before analysis. The signals were sampled continuously throughout the experiment with a sampling rate of 250 Hz.

1.5. Analysis

Epochs of the EEG corresponding to 1000 ms after word onset presentation were averaged and analyzed. Baseline correction was performed using the average EEG activity in

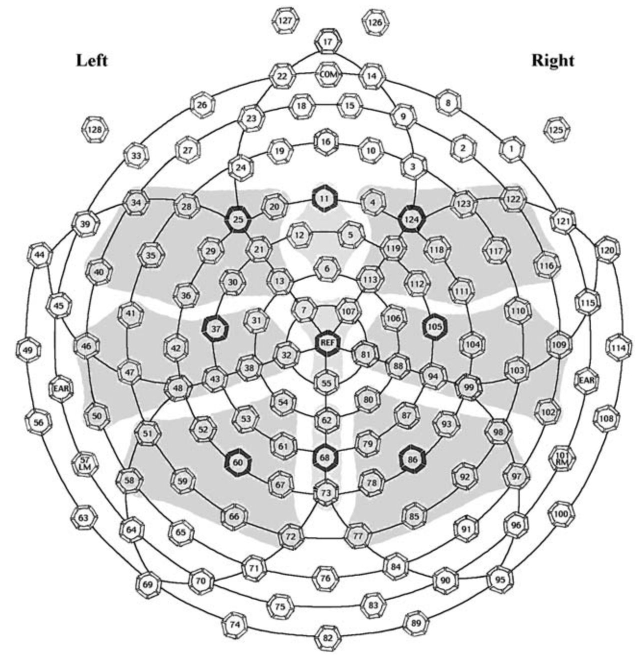

Fig. 1. Schematic flat representation of the 129 electrode positions from which EEG activity was recorded (front of head is at top). Channel nomenclature is by number. Approximate international 10–20 system localizations are marked. Electrodes included in the analyzed regions are highlighted in grey.

the 100 ms preceding the onset of the target word as a reference signal value. Following baseline correction, epochs with simultaneous artifacts in at least 10 channels were rejected. This operation resulted in the exclusion of approximately 13% of the trials, which were evenly distributed among the different experimental conditions. Furthermore, electrodes with a high level of rejected trials (>10%) were substituted by the average value of the group of nearest electrodes.

Nine regions of interest were computed out of the 129 electrodes, each containing the mean of a group of electrodes. The regions were (see electrode numbers in Fig. 1) the following: midline anterior (5, 6, 11 and 12), midline central (7, 55, 107 and 129), midline-central posterior (62, 68 and 73), left anterior (13, 20, 21, 25, 28, 29, 30, 34, 35, 36 and 40), left central (31, 32, 37, 38, 41, 42, 43, 46, 47, 48 and 50), left posterior (51, 52, 53, 54, 58, 59, 60, 61, 66, 67 and 72), right anterior (4, 111, 112, 113, 116, 117, 118, 119, 122, 123 and 124), right central (81, 88, 94, 99, 102, 103, 104, 105, 106, 109 and 110) and right posterior (77, 78, 79, 80, 85, 86, 87, 92, 93, 97 and 98).

The analyses were carried out in different temporal windows on the basis of calculations of mean amplitude values. Different repeated measures ANOVAs for each type of measures were performed, including the attachment (high or low) as a within factor. In addition, electrode regions (anterior, central and posterior) were entered as another within-subject factor. Separate analyses were carried out for the midline regions and the lateral regions. Analysis of the lateral regions included the hemisphere factor with two levels (left/right). A significance level of 0.05 was adopted for all the statistical tests. Where appropriate, critical values were adjusted using the Greenhouse–Geisser [23] correction for violation of the assumption of sphericity. Effects related to the electrode region factor or hemisphere factor will be only reported when they interact with the experimental manipulations. In cases of interaction of any experimental factor with the electrode region or hemisphere, data were normalized following the maximum–minimum procedure recommended by McCarthy and Wood [34].

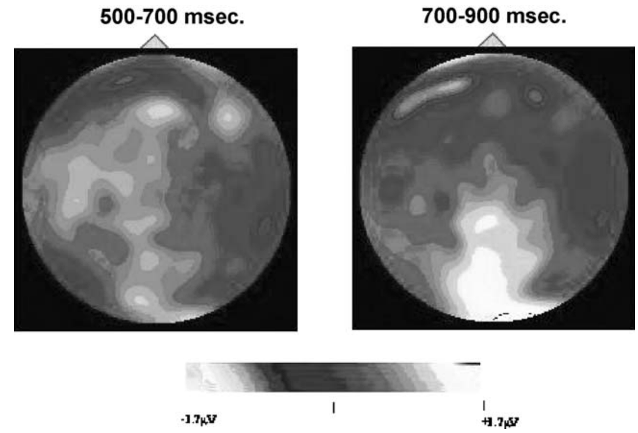

Fig. 3. Topographical maps obtained by interpolation from 128 electrodes at 500–700 and 700–900 time windows. Maps were computed from values resulting from the subtraction between high and low attachment conditions.

2. Results

The ERP grand averages for the high and low attachment conditions, time-locked to the onset of the target disambiguating word in the relative clause—e.g., the participle "premiada"—are represented in Fig. 2 over nine recording sites. Visual inspection of the figure reveals clear differences between the high and low attachment conditions. These differences are observed both in the 500–700 ms window and in the 700–1000 ms window (the same time windows were used by Kaan and Swaab [29]). Between 500 and 700 ms, low attachment waves were more positive-going than those in the high attachment condition. These effects seem to be very widely distributed, but especially on the left side of the scalp. Between 700 and 1000 ms, low attachment waves were again more positive-going than those in the high attachment condition, but especially in central and posterior sites. Thus, as can be seen in Fig. 2, waveforms start to diverge approximately at about 500 ms after the critical word, with a positive shift for the nonpreferred condition. This positive shift has an initial phase (500–700 ms window) in which it is roughly equally distributed over anterior and posterior sites. This early phase is followed by a later one (700–1000 ms window) with a more posterior distribution (see Fig. 3).

Statistical analysis supported these observations. The ANOVA with the average values of the 500–700 ms time epoch, including the factor *attachment* (high vs. low) and the factor *electrode regions* (anterior, central and posterior), showed a main effect of *attachment* in the midline analysis ($F_{1,26}=5.37$; $p<0.05$). The interaction between both factors was not reliable ($F_{1,26}=1.36$; $p>0.1$). In the lateral regions analysis, the ANOVA including *hemisphere* (left vs. right)

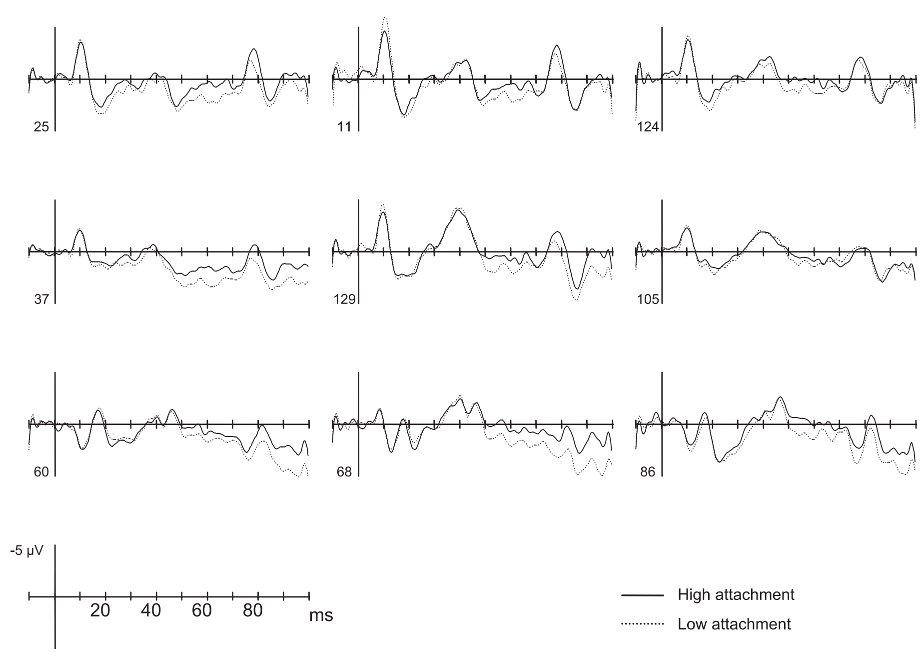

Fig. 2. ERPs to the target words for the high and low attachment conditions. Three midline, three left and three right hemisphere electrodes sites are shown. Negative amplitude is plotted upward.

as an additional factor showed again a main effect of *attachment* ($F_{1,26}=6.49$; $p<0.05$). None of the interactions with the factor *attachment* were reliable [*attachment* by *hemisphere* ($F_{1,26}=1.58$; $p>0.1$); *attachment* by *electrode* ($F<1$); *attachment* by *hemisphere* by *electrode* ($F<1$)].

The ANOVAs for the time epoch from 700 to 1000 ms with the same factors as the previous window in the midline analysis, *attachment* and *electrode* regions, revealed a significant main effect of *attachment* ($F_{1,26}=4.92$; $p<0.05$), as well as an interaction between the *attachment* and the *electrode regions* marginally significant ($F_{2,52}=3.60$; $p=0.06$; $\varepsilon=0.59$), interaction that was significant after the data normalization ($F_{2,52}=5.89$; $p<0.05$; $\varepsilon=0.62$). The attachment differences were only present in the posterior electrode region ($t=2.70$; $p<0.05$). In the lateral regions analysis, the ANOVA with the average values of the 700–1000 ms time epoch, including the factor *attachment* (high vs. low), the factor *electrode regions* (anterior, central and posterior) and the factor *hemisphere* (left vs. right), revealed a marginally significant main effect of attachment ($F_{1,26}=4.16$; $p=0.051$), as well as an interaction between the *attachment* and the *electrode regions* ($F_{2,52}=5.07$; $p<0.05$; $\varepsilon=0.60$), the interaction that was maintained after data normalization ($F_{2,52}=6.04$; $p<0.05$; $\varepsilon=0.63$). The attachment differences were only present in the posterior electrode region ($t=3.05$; $p<0.01$). None of the other interactions were significant.

3. Discussion

The main goal of the present experiment was to investigate whether electrophysiological evidence from Spanish readers converged with previous behavioural data indicating a bias to initially interpret a relative clause as modifying NP1 in structures such as NP1 of NP2 RC. The present results thus provide clear additional experimental evidence consistent with previous findings of a high attachment preference in Spanish [3–5,7] by showing that "violation" of preferred structural assignments elicited substantial positive shifts in the P600 ERP waveform.

The P600 effect has been taken as an indicator of syntactic processing cost in general. This processing cost was enhanced after an initial attachment that had to be revised because the relative clause disambiguated later towards the structurally nonpreferred attachment. In other words, the finding of a P600 when the RC disambiguates the previous string towards a nonpreferred structure shows that our parser has built up a measurable preference for one continuation (high attachment) over the other (low attachment). After the ambiguity was acknowledged, the high attachment continuation was initially more likely than the low attachment. Therefore, the ERP data seem to suggest that syntactic revision or reanalysis is at work, after an input that is incompatible with the analysis pursued is attached to the representation. Nonetheless, what our data cannot speak about is whether this preferred attachment is produced because the parser is taking into account statistical information (as the Tuning hypothesis proposes) or other extrasyntactic information (as, for instance, the Construal hypothesis proposes). The P600 effect leaves room for considering extrasyntactic information during revision, reanalysis or repair processes. However, the present ERP data seem to provide evidence for discarding the original idea from the Garden Path model of sentence processing that initial attachments of RCs are made based on a locality principle such as late closure. If that was the case, a LAN effect or an initial P600 effect should be expected in the opposite direction.

In contrast to the results obtained by Deutsch and Bentin in Hebrew and by Schmitt et al. in German for semantic gender agreement violation, no N400 effect appeared. Although German, Hebrew and Spanish are languages with a richly inflected morphology in which agreement plays a relevant role in building the syntactic structure, there are important differences between the gender systems of these languages that could be producing this discrepancy in the results. Different structures have also been studied in these experiments, and it could be also considered that the nature of the agreement violation in these three investigations is different. In any case, our results fit better with other studies that did not find the N400 effect in gender agreement violations when these implied semantic gender [38].

The second goal was to examine the electrophysiological patterns related to attachment ambiguity when there was not a strictly syntactic violation but the parser had to choose between a preferred and a nonpreferred attachment. The P600 effect has generally been associated with processes of revision, repair and reanalysis: input words that are ungrammatical given the preceding sentence context or incompatible with the preferred analysis of the preceding sentence context have systematically shown a P600 effect [6,24,26,29,40]. This effect has also been found with an increase of complexity for syntactic integration [21,29]. The results of the experiment reported here extend previous findings suggesting that the P600 reflects revision processes since a positivity was elicited at words that were grammatical continuations of the preceding sentence context. In addition, they also provide empirical support for the hypothesis that the P600 is not a monolithic effect, but a family of effects [20,21,24,29]. The present data show a biphasic P600 effect, one with a fairly equal distribution along the anterior posterior axis and a second with a clear posterior distribution. The first window of the P600 (500–700 ms) seems to be widely distributed, as was attested by the main effect of the attachment factor and the lack of interactions with the other factors, while the second window (700–900 ms) shows the usual posterior distribution.

While the P600 effect with a posterior distribution was generally found for ungrammatical sentence continuations [6], a more frontal/broad distribution of the positivity has been reported for nonpreferred continuations [19,26,37,40;

see, however, Ref. 29 for a posterior distribution with ambiguous nonpreferred continuations]. Hagoort et al. [24,26] proposed that the P600 with posterior distribution for ungrammatical continuations reflects costs associated with the repair or reanalysis processes necessary to fix the structural representation, while the P600 with a more frontal/broad distribution for nonpreferred continuations would reflect costs associated with overwriting the preferred, most active structural representation of the sentence. However, other authors (e.g., [Refs,21,29,30]) have proposed that the frontal positivity is not restricted to revision processes for ambiguous sentence structures, but is also found with increasing complexity, and posterior positivity may not be restricted to repair processes. In fact, Kaan and Swaab [29] found a frontally distributed P600 effect when complex ambiguous sentence structures were compared with simple grammatically correct unambiguous sentence structures, but a posterior distribution for nonpreferred continuations. Our data are partially consistent with the proposal put forward by Hagoort et al. [24,26] although the complexity of our sentences was similar in both experimental conditions, and a broadly distributed positivity was still found in the first window for the nonpreferred continuation (500–700 ms). However, at the same time, the finding of a posterior distribution with these same sentences in the second window (700–900 ms) is inconsistent with their proposal that the two parts of the P600 are elicited by different types of syntactic problems—revision processes for nonpreferred vs. repair processes for ungrammatical. Clearly, in our experiment, both parts of the P600 have been elicited by the processing of a single type of sentence which was never syntactically incorrect, but in addition, the second phase of the P600 with a more posterior-oriented distribution has been found with nonpreferred continuations. On the other hand, our data are partially consistent with the other proposal sustained by Kaan et al. [30] and Friederici et al. [21,29] since a more posterior distribution was found with nonpreferred sentences in the second window (700–900 ms). According to this proposal, the posterior positivity may not be restricted to repair processes for ungrammatical sentences but can be associated with more general syntactic processing difficulty, also including revision processes for nonpreferred continuations. However, the broadly distributed positivity that we found in the first window (500–700 ms) for the nonpreferred continuation does not agree with the idea that frontal and/or more distributed positivity is related with increases of complexity or with ambiguity resolution, as the ambiguity/complexity of our sentences was similar in both experimental conditions. Therefore, our data would fit with theoretical proposals that the late posterior distributed positivity may reflect not only repair, but also revision, and that the more early frontal/broadly distributed positivity may reflect not only ambiguity, but also potential problems with such ambiguity. One such theoretical framework may be the diagnosis and repair model proposed by Fodor and Inoue [14] that distinguishes two aspects of the revision process: the process of diagnosing the need for reanalysis and the actual reanalysis itself. The positivity between 500 and 700 ms may be a reflection of diagnosis. The late positivity between 700 and 900 ms may then be related to the final step of carrying out revisions or repairs. Firstly, assuming that our subjects were only aware of the ambiguity/complexity when they read the low attachment continuations and this process triggered the diagnosis stage, but not when they read the high attachment continuations, our data at the 500–700 window would fit with the frontal/broadly distributed positivity effects of complexity/ambiguity obtained by Friederici et al. [21] and by Kaan and Swaab [29]. Secondly, in the late more posterior positivity (700–900), we obtained fits with the revision–repair stage and with the data reported for syntactic processing reanalysis related either to revision (nonpreferred continuations) or to repair (ungrammatical continuations) [21,24,25,29].

In sum, the data point to the P600 as a family of effects reflecting similar, but nevertheless separable aspects of syntactic processing [cf. 20,21]. To identify the particular cognitive processes that the different parts of the P600 are reflecting is a matter of future investigation.

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