

THE PROCESSING OF NUMBER AND GENDER AGREEMENT IN SPANISH:  
AN ERP INVESTIGATION

BY

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## **ABSTRACT**

The present ERP (Event-related Potential) study investigates how syntactic agreement is processed at the electrophysiological level, examining whether the parser is sensitive to the structural distance between the agreeing elements and whether different agreement categories (number, gender) are processed similarly. Participants read Spanish sentences while EEG (Electroencephalogram) was recorded from 29 scalp electrodes. Results show that number and gender agreement violations yielded a similar P600, a positive wave between 400 and 900ms peaking at 600ms. This ERP response is assumed to reflect the repair of morphosyntactic anomalies, including agreement mismatches (Osterhout & Mobley, 1995). Furthermore, no differences in P600 amplitude were observed for violations that were established across a syntactic phrase versus violations established within the same phrase. These results suggest that agreement is computed in a homogenous way regardless of the agreement category involved and of the syntactic distance between the agreeing elements.

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## 1. Introduction

Languages have different ways of indicating grammatical relations between some of the elements in a phrase or sentence. One of those mechanisms is grammatical agreement.<sup>1</sup> When two elements in a language enter an agreement relationship, they vary together in a systematic way. An example of this is provided in (1), using number agreement in Spanish:

(1)

- a. el libro  
the-SG book-SG  
“the book”
- b. los libros  
the-PL book-PL  
“the books”
- c. \*el libros  
the-SG book-PL  
Intended meaning: “the books”

In (1a), the singular noun *libro* “book” agrees in number (alongside gender) with the singular definite determiner *el*. When one of the elements in this agreement relationship—in most theoretical accounts, the noun—is then specified for plural, the other element must also be specified for plural for the phrase to be grammatical, as can be seen in (1b). Otherwise, the derivation crashes, as shown by the ungrammatical string in (1c), where there is a mismatch between the number value of the determiner and that of the noun.

Although the question is not undisputed, it is generally assumed that the relationship between agreeing elements is asymmetric. This is particularly obvious with grammatical gender. In languages that instantiate grammatical gender agreement (i.e., Spanish), the

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<sup>1</sup> The other two main ways of indicating grammatical dependencies are word order and case-marking (Wechsler, 2009). Much of the discussion on agreement in this section is based on Wechsler, 2009.

gender value of the noun is generally invariable. For example, the Spanish noun in (2a), *caja* “box”, is and can only be feminine. This element is known as the *trigger*. By contrast, the gender value of the other element/s in an agreement relationship (in the phrases in (2), the determiner) is variable and must therefore inherit its feature value from the trigger, as can be seen in the phrases in (2). This element is referred to as the *target*.

- (2)
- a. la            caja  
   the-FEM box-FEM  
   “the box”
  
  - b. \*el           caja  
   the-MASC box-FEM  
   Intended meaning: “the box”

The present study is mainly concerned with the electrophysiological processing of two agreement categories—namely, number and gender—in Spanish, a language with a very rich agreement system.<sup>2</sup> As we are interested in agreement, we will adopt the trigger/target distinction above and focus, mainly, on the processing of number and gender agreement on adjectives, which are targets of agreement.<sup>3</sup>

Our study is inspired by and built upon a previous investigation by Barber & Carreiras (2005) on the electrophysiological processing of number and gender agreement in Spanish. In their study, Barber & Carreiras reported differences in the processing of number and gender agreement violations, with gender violations being costlier to repair than number mismatches (as indicated by the amplitude of the P600, a measure of neural activity that will be discussed in Section 3). The authors interpret these findings as evidence for Faussart et al.’s lexical retrieval model (1999), which

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<sup>2</sup> Alongside number and gender, languages (including Spanish) can also instantiate person agreement (Wechsler, 2009).

<sup>3</sup> We will also explore number and gender agreement measured on triggers, but to a lesser extent.

assumes that lexical information (i.e., gender) is processed at an earlier stage than syntactic information (i.e., number).<sup>4</sup> Therefore, after encountering a gender agreement violation, the parser must go back to the initial stage of lexical retrieval (identification) to check for gender. By contrast, when the parser encounters a number mismatch, it only has to go back to a later stage (recognition and integration) to check for syntactic information; hence, the greater processing costs for gender than for number.

In addition, Barber & Carreiras made the interesting proposal that the neurophysiological processing of agreement may be affected by the structural distance between the agreeing elements. More specifically, Barber & Carreiras (2005) observed that, when the agreeing elements in their stimuli were located within the same phrase, agreement violations were easier to repair than when the agreeing elements were located across phrases, as indicated by the amplitude of the P600. Samples of the within and across-phrase agreement violations in Barber & Carreiras are provided in (3) and (4), respectively. In the sentences in (3), the agreeing noun and determiner (underlined) are located within the same phrase, a Determiner Phrase. By contrast, in the sentences in (4), the agreeing noun and adjective (also underlined) are located across a Verb Phrase.

(3)

- a. el                      piano                      estaba viejo y      desafinado.  
the-MASC-SG piano-MASC-SG was      old      and      off-key  
“The piano was old and off-key”
- b. \*los                      piano                      estaba viejo y      desafinado.  
the-MASC-PL piano-MASC-SG was      old      and      off-key  
Intended meaning: “The piano was old and off-key”
- c. \*la                      piano                      estaba viejo y      desafinado.  
the-FEM-SG piano-MASC-SG was      old      and      off-key  
Intended meaning: “The piano was old and off-key”

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<sup>4</sup> Claims that number is a syntactic head and gender a lexical feature will be discussed in Section 2.

- (4)
- a. el faro es alto y luminoso.  
the lighthouse-MASC-SG is high-MASC-SG and bright  
“The lighthouse is high and bright”
  - b. \*el faro es altos y luminoso.  
the lighthouse-MASC-SG is high-MASC-PL and bright  
Intended meaning: “The lighthouse is high and bright”
  - c. \*el faro es alta y luminoso.  
the lighthouse-MASC-SG is high-FEM-SG and bright  
Intended meaning: “The lighthouse is high and bright”

(Adapted from Barber & Carreiras, 2005, p. 151)

Barber & Carreiras interpret these syntactic distance effects as evidence that repairing agreement violations across phrases requires the allocation of greater resources than repairing agreement mismatches within the same syntactic unit. A more careful examination of the experimental stimuli in Barber & Carreiras (2005), however, reveals that these are not the most desirable stimuli to test for distance effects in the electrophysiological processing of agreement. First of all, within and across-phrase agreement violations were not controlled for linear distance, the number of words between the agreeing elements. Therefore, when agreement was established within the same phrase, as in (3), the agreeing elements were adjacent. However, when agreement was computed across a phrase, as in (4), the agreeing elements were separated by one word, the copula *ser* “be”, inflected for third person singular. Therefore, the question arises whether the effects reported by Barber & Carreiras were really due to the syntactic distance between the agreeing elements or, rather, to the linear distance between them.

Another concern with the stimuli in Barber & Carreiras (2005) is that the syntactic category of the critical word—namely, the word where the agreement violations became noticeable—was not controlled for. Thus, within-phrase agreement mismatches, as in (3), were always noticeable on the noun, which is an agreement trigger where both the

number and gender features are assumed to be interpretable (Carstens, 2000). By contrast, across-phrase agreement violations, as in (4), always became noticeable on the adjective, which is an agreement target where the number and gender features are assumed to be uninterpretable (Carstens, 2000).

Summarizing, the stimuli in Barber & Carreiras (2005) were neither controlled for linear distance nor for the syntactic category of the critical word. Consequently, these stimuli do not allow us to systematically argue for syntactic distance effects in the electrophysiological processing of agreement. The question also arises whether the lack of control for the abovementioned factors could have been responsible for the differences that Barber & Carreiras reported for the number and gender features (recall that differences between number and gender were also found in the P600). The main aim of the present study is, therefore, to explore some of these open questions raised by Barber & Carreiras (2005) about the electrophysiological processing of number and gender agreement in Spanish. More specifically, the current study, which encompasses three experiments, has been designed to investigate the three following questions:

- 1) What electrophysiological effects do violations of gender and number agreement in Spanish elicit, when measured on a target of agreement (adjective)? What effects do they elicit when measured on an agreement trigger (noun)?
- 2) Are there any differences in the electrophysiological processing of number and gender agreement in Spanish?
- 3) Does syntactic distance affect the electrophysiological processing of agreement—regardless of agreement category—when linear distance is controlled for? Is agreement costlier when the agreeing elements are located across phrases?

The study is structured as follows. In section 2, an overview of the main theoretical accounts of the syntax of number and gender will be provided, alongside a brief description of the Spanish number and gender systems. In section 3, a succinct description of the electrophysiological method employed in the present study, namely, Electroencephalography (EEG) will be offered (focusing on the experimental paradigm used and the type of resolution provided), alongside an overview of the main event-related potentials reported in the sentence processing literature. In section 4, a critical review of the main bibliography on electrophysiological studies of agreement and syntactic distance/complexity will be presented, both for Spanish and other languages. In Sections 5 and 6, I will elaborate on the present study and its methodology (experiments, conditions, stimuli, tasks, and procedure). In section 7, I will present the preliminary results of the study. In section 8, I will discuss the main theoretical implications of our findings.

## **2. Theoretical Accounts of Number and Gender**

### **2.1. Number**

As pointed out in Bernstein (2001), there is little controversy in the literature regarding Ritter's (1991) proposal that number projects its own phrase somewhere between DP and NP. In her analysis of two types of Noun Phrases in Modern Hebrew—construct states (5a) and free genitives (6a)—Ritter provides evidence that the object noun (i.e., *house* in the examples below) raises in both constructions, but lands in different sites.<sup>5</sup> In construct states (5a), Ritter posits that the object noun is raised to D, which explains why noun and determiner are in complementary distribution, as shown by the ungrammatical string in (5b). However, in free genitives (6a), the object noun

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<sup>5</sup> For a detailed explanation of DP-internal noun movement in Modern Hebrew, see Ritter 1991.

head-moves to some position below DP and above NP, which Ritter assumes is Number Phrase (NumP) given that the material residing in that position (i.e., quantifiers) contributes to the specification of the DP for number.

(5)

a. [beyt]      ha-mora      *t*  
  
house      the-teacher  
“the teacher’s house”

b. \*ha-beyt      ha-mora  
the-house      the-teacher  
Intended meaning: “the teacher’s house”

(6)

a. ha-[bayit]      *fel*      ha-mora      *t*  
  
the-house of      the-teacher  
“the teacher’s house”

(Adapted from Ritter, 1991, p. 40-42)

In the present study, we will adopt Ritter’s proposal that Number projects its own phrase between DP and NP.<sup>6</sup> Furthermore, we will follow Cinque’s proposal (1994) that, in Romance, nouns move from their underlying position (post-adjectival) to some intermediate position below D, which, based on Ritter, we assume is Number Phrase. Once the noun has raised to Number Phrase, it enters an agreement relationship with other elements in the DP (i.e., determiners and adjectives).<sup>7</sup> The diagram in (8) contains a tree representation of Number Phrase for the DP in (7a). What is crucial for the purposes of the present study is that Ritter’s proposal is in line with Barber & Carreiras’ (2005) assumption that number is a syntactic (as opposed to lexical) feature and that a

<sup>6</sup> Bernstein (2001) points out that Ritter’s proposal has been well received and adapted to capture other languages, like French and Catalan. Bernstein (1991) herself provides evidence supporting Ritter’s approach using data from another romance language, Walloon.

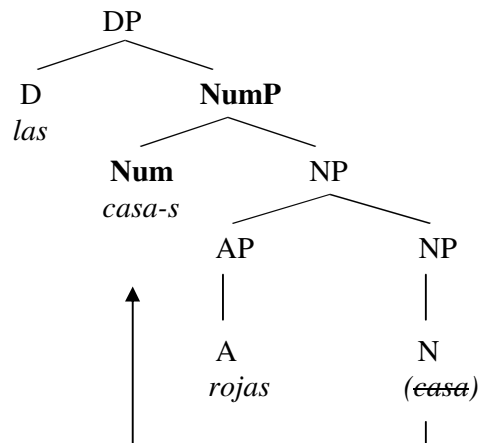
<sup>7</sup> Carstens, 2000.

violation of number agreement only requires that the parser check purely syntactic information.

(7)

- a. Las        casas        rojas  
       the-PL    houses-PL    red-PL  
       “The red houses”

(8)



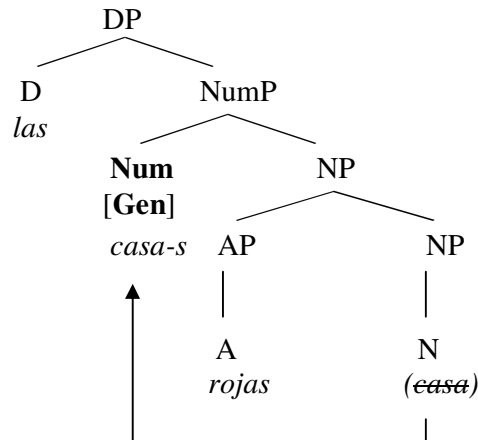
## 2.2. Gender

The theoretical proposals regarding the representation of gender in the syntax are not as unified as those for number (Bernstein, 2001). Based on the observation that knowledge of a noun involves knowing its (generally invariable) gender, Ritter (1991, 1993) posits that gender is part of the noun’s lexical entry and not a functional head. This approach to gender as a lexical feature has also been adopted by Carstens (2000). However, as far as the exact locus of gender is concerned, Ritter (1993) argues that there is parametric variation. For a Romance language like Spanish, she argues that gender is a feature on Num, which explains why gender switching is not a productive word formation strategy in Spanish—if gender is a feature on Num, it is not linked to the noun stem and, therefore, gender switching to derive new nouns is not available—



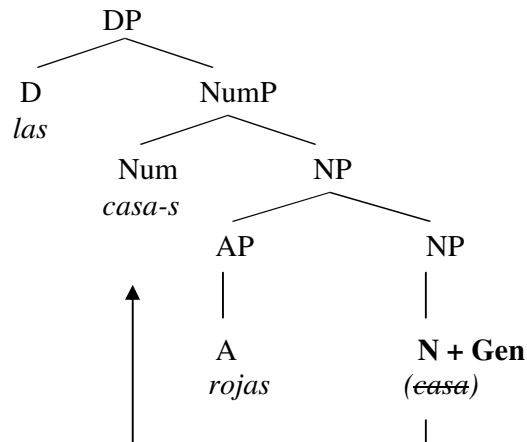
and why plural morphemes in Romance are specified for gender.<sup>8</sup> The tree in (9) includes a tree representation of Ritter’s proposal for gender in Romance, where the noun *casas* “houses” receives number and gender once it moves to NumP.

(9)



The diagram in (10) includes a tree representation of Carstens’ proposal for the locus of gender, where the noun *casas* “houses” appears as specified for gender under N (much in line with Ritter’s proposal for Hebrew):

(10)



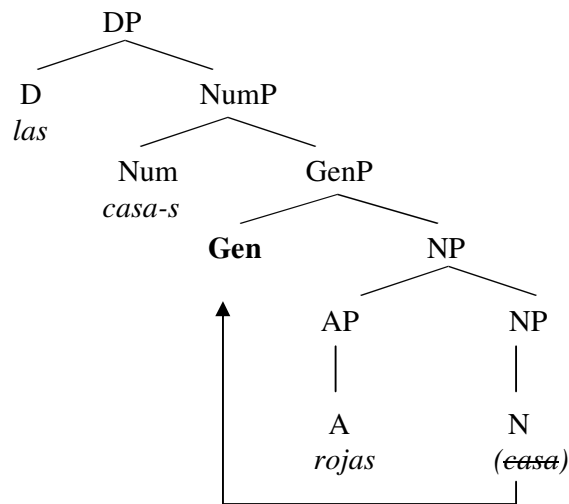
Crucially for the purposes of the present study, despite differences regarding the exact locus of gender, both Ritter and Carstens posit that gender is a lexical feature,

<sup>8</sup> By contrast, for a language like Modern Hebrew, where gender switching is a very productive word formation strategy and where plural morphemes are not specified for gender—some feminine nouns take masculine plural morphemes and vice versa—Ritter argues that gender is located under N.

which is in line with Barber & Carreiras' (2005) assumption that gender agreement violations—contrary to number mismatches—require that the parser go back to the earliest stage of lexical retrieval (identification) to check for lexical information.

Finally, a rather different proposal about the representation of gender in the syntax can be found in Picallo (1991), who posits that—like number—gender projects its own phrase (Gender Phrase), below NumP and above NP. In Picallo's model, nouns raise to GenP to receive gender and then, to NumP to receive number. The diagram in (11) includes a tree representation of Picallo's proposal. It is important to keep in mind that Picallo's model predicts no differences in the processing of number and gender (as measured in the late P600), as both features are assumed to project their own phrase. Therefore, for both number mismatches and gender agreement violations, the parser has to go back to the same stage (integration) to check for number or gender information (see Faussart et al., 1999 for a similar interpretation of the predictions by Picallo's model regarding the online processing of number and gender).

(11)



## 2.3. Number and Gender in Spanish

### 2.3.1. Number Morphology in Spanish

A very descriptive account of the morphological realization of number in Spanish nouns and adjectives is provided in Saporta (1965), who posits that Spanish plurals are formed in three different ways depending upon the phonetic properties of the root. If the root ends in an unstressed vowel, the plural is formed by suffixing the allomorph [-s] to the root, as shown in (12a) and (12b). If the root ends in a stressed vowel or in a consonant other than [-s], as in (13a) and (13c) respectively, the plural is formed by suffixing the allomorph [-es] to the root, as shown in (13b) and (13d). Finally, if the root ends in [-s] and has more than two syllables, as in (14a), plural is unmarked.

(12)

- |         |          |
|---------|----------|
| a. casa | b. casas |
| house   | house-PL |
| “house” | “houses” |

(13)

- |         |           |
|---------|-----------|
| a. tabú | b. tabúes |
| taboo   | taboo-PL  |
| “taboo” | “taboos”  |
| c. mar  | d. mares  |
| sea     | sea-PL    |
| “sea”   | “seas”    |

(14)

- |           |           |
|-----------|-----------|
| a. crisis | b. crisis |
| crisis    | crisis-PL |
| “crisis”  | “crises”  |

As will be mentioned later in Section 6 (Methods), the only elements that exhibit plural morphology in the present study are nouns, adjectives, and determiners. While it is true that Spanish marks number in other elements (i.e., complementizers, verbs, or pronouns), those elements are not tested in our investigation and, therefore, I will leave them aside. As far as the nouns and adjectives in the current study are concerned, they

all end in unstressed vowels and, therefore, select for the [-s] plural allomorph (as in 12). As for the determiners, we only tested one set of demonstratives, whose plural forms are provided below both for the masculine (15) and for the feminine demonstrative (16):

- (15)
- |                                   |                                    |
|-----------------------------------|------------------------------------|
| a. este<br>this-MASC-SG<br>“this” | b. estos<br>this-MASC-PL<br>“this” |
|-----------------------------------|------------------------------------|
- (16)
- |                                  |                                   |
|----------------------------------|-----------------------------------|
| a. esta<br>this-FEM-SG<br>“this” | b. estas<br>this-FEM-PL<br>“this” |
|----------------------------------|-----------------------------------|

### 2.3.2. Spanish Gender System

The Spanish gender system is significantly less transparent than the number system. In Spanish, nouns are assigned to one of two genders, masculine or feminine. For inanimate nouns, which will be the focus of the present study, lexical gender is assigned arbitrarily, as shown by (17), where two synonymous nouns show different lexical genders.<sup>9</sup> By contrast, for nouns referring to human beings, lexical gender and biological sex largely overlap, as shown by the examples in (18), although there are exceptions (i.e., *víctima* “victim” is invariably feminine regardless of the sex of its referent).<sup>10</sup>

- (17)
- |                                     |   |
|-------------------------------------|---|
| a. domicilio<br>home-MASC<br>“home” | b. residencia<br>residence-FEM<br>“residence” |
|-------------------------------------|---|

---

<sup>9</sup> Examples are from Harris (1991, # 11a).

<sup>10</sup> Examples are from Harris (1991, # 16).

- (18)
- a. tío  
uncle-MASC  
“uncle”
  - b. tía  
aunt-FEM  
“aunt”

Spanish marks gender on most of the elements where Corbett (1991) observes that languages realize gender agreement, namely, determiners, nouns, pronouns, adjectives, a few numerals, and complementizers.<sup>11</sup> For the purposes of the present study, we will focus on agreement on adjectives, as in (19)—where the feminine noun *casa* “house” must agree in gender with the adjective *roja* “red”—and demonstratives, as in (20), where the feminine noun *casa* must agree in gender with the demonstrative *esta* “this”:

- (19)
- a. casa            roja  
house-FEM red-FEM  
“red house”
  - b. \*casa            rojo  
house-FEM red-MASC  
“red house”

- (20)
- a. esta            casa  
this-FEM house-FEM  
“this house”
  - b. \*este            casa  
this-MASC house-FEM  
“this house”

It is important to keep in mind that neither of the two genders in the Spanish system is associated with a unique form. On the contrary, Harris (1991) proposes that both genders can exhibit every one of the seven word markers that he identifies for the

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<sup>11</sup> Corbett also mentions that gender agreement can be marked on adverbs and verbs, although this is not the case for Spanish.

language. Therefore, despite the apparent correlation between the masculine and feminine genders and the suffixes *-o* and *-a*, respectively, Harris (1991) argues that these suffixes are not gender morphemes, but word markers. Further evidence for Harris' proposal comes from the fact that some Spanish adverbs, which are never marked for gender, bear those exact same word markers (i.e., *dentr-o* "inside", *fuer-a* "outside").<sup>12</sup> Although Harris' proposal should be kept in mind, the author himself points out that when a masculine noun or adjective exhibits a vowel marker, that marker is usually *-o*. Likewise, when a feminine noun or adjective exhibits a vowel marker, it is usually *-a*. For that reason, it was decided that the present study would only include masculine nouns ending in *-o* and feminine nouns ending in *-a*.

In the next section, the brain imaging method used in the present study will be introduced.

### **3. Brain Imaging Method**

#### **3.1. Electroencephalography (EEG) and Event-Related Potentials (ERPs)**

Electroencephalography (EEG) is the recording of electrical activity generated by groups of neurons inside the brain. Being an electrophysiological method, EEG provides excellent temporal resolution (at the level of milliseconds) and is, therefore, mainly used to investigate the temporal aspects of a series of events (in the present study, different types of ungrammaticalities). However, because electricity is very sensitive to its conductor (the path electricity will follow will depend on the conductivity of the brain tissues surrounding its neural generator), this method provides poor spatial resolution and is, therefore, rarely used to localize the neural sources of the process under investigation.

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<sup>12</sup> Examples are from Harris (1991, # 7a-b).

Event-related brain potentials (ERP) are voltage changes measured on the scalp that are time-locked to the onset of particular events (in the present study, different types of morphosyntactic violations). When examining event-related potentials, a number of factors (i.e., amplitude, peak latency, etc.) can be of interest, depending upon the nature of the investigation. For the purposes of the current study, this discussion will focus on the following factors: the presence or absence of a given component of interest, its latency, its amplitude, and its topography.<sup>13</sup>

The latency of a component refers to the time when the waveforms for the conditions being compared diverge from one another. As an illustration, violations of semantic appropriateness like the one in (21b) typically elicit a more negative wave than their grammatical counterpart between 300 and 600ms (data from Kutas & Hillyard, 1980).<sup>14</sup> Oftentimes, event-related potentials have a distinct peak latency, which refers to the point where the component reaches its maximum amplitude (Handy, 2004). In the case of the negative wave described for semantic violations like (21b), this component canonically reaches its peak at 400ms (Kutas & Hillyard, 1980); hence its name: N400 (*N* = Negative wave, *400* = peak at 400ms).

- (21)
- a. He spread the warm bread with butter.
  - b. He spread the warm bread with \*socks.

(21b adapted from Kutas & Hillyard, 1980, p. 203)

For its part, the amplitude of an event-related potential is the intensity of the voltage change measured on the scalp. The amplitude of a given ERP is thought to reflect the allocation of resources to the processing of a particular stimulus or the reaction to a motor response. As an example, the amplitude of the aforementioned N400 is negatively

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<sup>13</sup> For a more comprehensive and explanatory list of factors (peak-to-peak latency, onset latency, et cetera), see Handy, 2004.

<sup>14</sup> Measured on the critical word, the word where the violation becomes noticeable (underlined in 21a and 21b).

correlated with the predictability of the critical word (Kutas & Hillyard, 1980). The less predictable the word is, the greater the amplitude of the N400, as greater resources will be required to integrate the word into the sentence.

Finally, the topography of an ERP indicates the location of the electrode or array of electrodes recording the voltage change on the scalp, rather than the neural generators of the electrophysiological activity (Handy, 2004). For instance, the N400 is said to have a central-parietal distribution, as its maximum peak is traditionally captured by central and parietal electrodes (Kutas & Hillyard, 1980).

## **3.2. Main Event-Related Potentials Reported for Sentence Processing**

### **3.2.1. Semantics**

In the realm of semantics, the ERP component that has received the greatest attention is the aforementioned **N400**, a negative deflection that reaches its peak approximately 400ms after stimulus presentation in central and parietal electrodes (Kutas & Hillyard, 1980). Although this component is elicited by all of the content words in a given sentence, there is abundant evidence in the literature that the N400 elicited by words that are semantically related to a previously presented prime show a significant reduction in amplitude (Holcomb & Neville, 1990). There is also ample evidence that the amplitude of the N400 is inversely correlated with the semantic or pragmatic appropriateness of the eliciting word in a sentence (Kutas & Hillyard, 1980; Nieuwland & Van Berkum, 2006; Hagoort, Hald, Bastiaansen, & Petersson, 2004) and with the semantic congruency of the sentence itself (Van Petten, 1993). Importantly, as shown by Kutas & Hillyard (1980), the N400 is not modulated by lower-level factors like unexpected letter sizes, which suggests that this component is affected by a specific type of predictability, semantic and pragmatic predictability. Crucially for the purposes



of the present study, the N400 is not usually reported for morphosyntactic violations, unless the latter involve semantic information, as is the case with a violation of biological gender agreement (i.e., Deutsch & Bentin, 2001) or an argument structure violation (i.e., Frisch, Hahne, & Friederici, 2004), which are argued by some to belong to the domains of both syntax and semantics.

### 3.2.2. Morphosyntax

As far as syntax and morphosyntax are concerned, the picture is significantly more complicated. The event-related potentials that have been most systematically investigated are the Early Left Anterior Negativity (Friederici, Hahne, & Mecklinger, 1996; Lau, Stroud, Plesch, & Phillips, 2006; Ye, Luo, Friederici, & Zhou 2006; Neville, Nicol, Barss, Forster, & Garrett, 1991), the Left Anterior Negativity (Coulson, King, & Kutas, 1998; Friederici, Hahne, & Mecklinger, 1996; Krott, Bayern, & Hagoort, 2006) and the P600 (Hagoort & Brown, 1993; Osterhout & Mobley, 1995; Friederici, Hahne, & Mecklinger, 1996; Kaan & Swaab, 2003a; Kim & Osterhout, 2005; Gouvea, Phillips, Kazanina, & Poeppel, 2009).

As indicated by its name, the Early Left Anterior Negativity, also referred to as ELAN, is a negative deflection that peaks very early, approximately between 100 and 300ms post stimulus presentation, in left anterior electrodes. Under Friederici's model of auditory sentence comprehension (Friederici, 2002), the ELAN is triggered by the impossibility to assign a phrase structure to the incoming input, as in (22b) below, where the preposition *of* can no longer be inserted into the previous phrase structure:

- (22)
- a. The scientist criticized Max's proof of the theorem.
  - b. The scientist criticized Max's \**of* proof the theorem.

(Adapted from Neville et al., 1991, p. 154)

According to Friederici, phrase structure building is a highly automatic process that relies exclusively on word category information (Friederici et al., 1996; Ye et al., 2006). Evidence that the ELAN does indeed reflect first-pass automatic processes comes from Hahne & Friederici (1999), who show that this component is unaffected by probability manipulations and is, therefore, elicited by phrase structure violations regardless of their likelihood. In addition, the ELAN has also been reported for languages that are very morphologically impoverished and do not mark syntactic category overtly (e.g., Chinese), providing evidence for Friederici's proposal that the processes indexed by the ELAN are purely guided by word category information and not by morphological markers (Ye et al., 2006; but see Dikker et al., 2009).

Although there is ample evidence that the ELAN is highly sensitive to violations of word category, other studies suggest that this component may reflect the violation of a strong syntactic prediction that the parser makes based on word category information (Lau, Stroud, Plesch, & Phillips, 2006). In addition, the ELAN has also been shown to be sensitive to lower-level factors like the physical properties of the stimuli (Gunter, Friederici, & Hahne, 1999) or the presentation modality (Frisch, Hahne, & Friederici, 2004). Crucially for the purposes of the present study, the ELAN is not usually reported for agreement violations (but see, for example, Deutsch & Bentin, 2001).

The **Left Anterior Negativity**, also called **LAN**, is an ERP component with similar topography to the ELAN (left anterior), but with different latency (300-500ms post stimulus presentation). Under Friederici's model of sentence comprehension, the LAN is hypothesized to index morphosyntactic processing, including failure to perform agreement or to check for case (In Spanish: Barber & Carreiras, 2005; In German: Rossi, Gugler, Hahne, & Friederici, 2005; Gunter, Friederici, & Schriefers, 2000; Friederici, Hahne, & Mecklinger, 1996; In Italian: Molinaro, Vespignani, & Job, 2008;

De Vincenzi, Job, Di Matteo, Angrilli, Penolazzi, Ciccarelli, & Vespignani, 2003; In English: Coulson et al., 1998). The sentence in (23b) below, where the German neuter *Land* disagrees in gender with the masculine determiner *den*, is an example of the type of morphosyntactic violation that Friederici's model predicts to elicit a Left Anterior Negativity:

(23)

- a. Sie bereist das Land auf einem Kraftigen Camel  
she travels the-NEUT land-NEUT on a strong camel  
“She travels the land on a strong camel”
  
- b. Sie bereist den \*Land auf einem Kraftigen Camel  
she travels the-MASC land-NEUT on a strong camel  
Intended meaning: “She travels the land on a strong camel”

(Adapted from Gunter et al., 2000, p. 559)

Nevertheless, it must be pointed out that some studies investigating a variety of morphosyntactic violations—including agreement—in different languages have failed to report this Left Anterior Negativity (in Spanish: Wicha, Moreno, & Kutas, 2004; Martín Loeches, Nigbur, Casado, Hohlfeld, & Sommer, 2006; in Dutch: Hagoort, 2003). In addition, the LAN has been reported for a variety of factors other than morphosyntactic mismatches. For example, Kaan & Swaab (2003b) found a LAN for syntactically ambiguous sentences, suggesting that this component might be related to syntactic integration difficulty (but see Gouvea, Phillips, Kazanina, & Poeppel, 2009 for an alternative explanation more in line with Friederici's proposal). For their part, Kluender & Kutas (1993) posit that the LAN may reflect working memory load. Finally, Krott, Baayen, & Hagoort (2006) provide evidence that the LAN may reflect the violation of a morphosyntactic prediction.

Finally, the **P600**, also referred to as **Syntactic Positive Shift** (SPS), is a late positive wave between 500 and 900ms that reaches its maximum at approximately

600ms over posterior (central-parietal) electrodes. Under Friederici's proposal, the P600 is thought to reflect controlled processes like syntactic and morphosyntactic repair, including agreement mismatches like the one in (23b) above (in Dutch: Hagoort, Brown, & Groothusen, 1993; Hagoort & Brown, 1999; in English: Osterhout & Mobley, 1995; Gouvea et al., 2009; in Spanish: Barber & Carreiras, 2005; in Hebrew: Deutsch & Bentin, 2001; in German: Gunter et al., 2000; Schmitt, Lamers, & Münte, 2002; in Italian: De Vincenzi et al., 2003; Molinaro et al., 2008). The P600 has also been argued to index syntactic integration difficulty (Kaan, Harris, Gibson, Holcomb, 2000; Phillips, Kazanina, & Abada, 2005; Gouvea et al., 2009), as it can be found in sentences requiring syntactic integration due to the presence of a displaced *wh*-word, as in (24b), relative to sentences where no integration is necessary, as in (24a).<sup>15</sup>

(24)

- a. Emily wondered whether the performer in the concert had imitated a pop star for the audience's amusement.
- b. Emily wondered who the performer in the concert had imitated t for the audience's amusement.

(Adapted from Kaan et al., 2000, p. 164)

Finally, evidence has also been provided that the P600 reflects syntactic reanalysis (Osterhout & Holcomb, 1992; Gouvea et al., 2009), as it has been reported for garden path sentences like the one in (25b), where the parser is temporarily misled into the incorrect phrase structure, relative to their unambiguous counterparts (25a):

(25)

- a. The patient met the doctor while the nurse with the white dress *showed* the chart during the meeting.
- b. The patient met the doctor and the nurse with the white dress *\*showed* the chart during the meeting.

(Adapted from Gouvea et al., 2009, p. 9)

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<sup>15</sup> Crucially, the fact that the sentence in (24b) is perfectly grammatical and unambiguous also suggests that the P600 is not simply a response to the detection of a violation.

Evidence that the P600 does indeed reflect controlled processes comes from Hahne & Friederici (1999), who show that the P600 can be suppressed when the expectation of being presented with a syntactic violation is very high. In addition, differences in the scalp distribution of the P600 have been argued to index different processes. For example, Hagoort, Brown, & Osterhout (1999) argue that the P600 is frontally distributed when it indexes reanalysis, and posteriorly distributed when it indexes repair. By contrast, other authors (Friederici, Hahne, & Saddy, 2002; Kaan & Swaab, 2003a) have posited that the frontal P600 indexes complexity.

Finally, some authors (Hagoort & Brown, 2000; Barber & Carreiras, 2005; Molinaro et al., 2008) have suggested that the P600 can be divided into two distinct phases indexing different factors and exhibiting different scalp distributions. The logic behind this proposal is that these two different portions of the P600 are not equally affected by different types of violations, suggesting that they are sensitive to different morphosyntactic factors. More specifically, the early phase of the P600, whose latency corresponds to the 500-700ms time-window, is associated with reintegration and shows a broad scalp distribution. By contrast, the late phase of the P600, whose latency corresponds to the 700-900ms time window, is associated with reanalysis or repair and shows an almost exclusively posterior distribution (Hagoort & Brown, 2000).

As mentioned earlier, the present study is an ERP study on the processing of number and gender agreement in Spanish. After having introduced the main ERPs associated with different types of violations, including agreement, a critical review of the most relevant literature on the electrophysiological processing of agreement will now be offered.

## **4. Literature Review**

### **4.1. The Electrophysiological Processing of Agreement**

A considerable number of studies have investigated the electrophysiological processing of agreement. These studies, which have focused on agreement processes for a variety of reasons, have examined different types of concord (i.e., number, person, or gender) and used a relatively wide range of languages. In the next section, the studies focusing on agreement in Spanish will be briefly reviewed.

#### **4.1.1. ERP Studies on the Processing of Agreement in Spanish**

Barber & Carreiras (2005) investigated the electrophysiological processing of number and gender agreement in Spanish in order to test proposals suggesting that these two features are essentially distinct and occupy different positions in the syntax (Ritter, 1993). Previous behavioral studies examining frequency effects (Domínguez, Cuetos, & Seguí, 1999), priming effects (Faussart, Jakubowitz, & Costes, 1999), and attraction errors (Antón-Méndez, Nicol, & Garrett, 2002) have indeed reported differences in the processing of these two features. By contrast, other studies (Lukatela, Kostic, Todorovic, Carello, & Turvey, 1987; Colé & Seguí, 1994) have found that both features behave in a very similar way. The aim of the Barber & Carreiras study was, therefore, to analyze whether the processing of gender and number agreement differed at the electrophysiological level.

In one of their experiments, the authors compared number and gender agreement violations in non-sentential contexts. The stimuli in their study consisted of noun-

adjective and determiner-noun pairs manipulating number and gender agreement, as can be seen in (25) and (26) below.<sup>16</sup>

(25)

**Grammatical**

- a. faro                                  alto  
lighthouse-MASC-SG   high-MASC-SG  
“high lighthouse”

**Number Violation**

- b. faro                                  \*altos  
lighthouse-MASC-SG   high-MASC-PL  
Intended meaning: “high lighthouse”

**Gender Violation**

- c. faro                                  \*alta  
lighthouse-MASC-SG   high-FEM-SG  
Intended meaning: “high lighthouse”

(26)

**Grammatical**

- a. el    piano  
the-MASC-SG   piano-MASC-SG  
“the piano”

**Number Violation**

- b. los                                        \*piano  
the-MASC-PL   piano-MASC-SG  
Intended meaning: “the piano”

**Gender Violation**

- c. la                                         \*piano  
the-FEM-SG   piano-MASC-SG  
Intended meaning: “the piano”

(Adapted from Barber & Carreiras, 2005, p. 150)

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<sup>16</sup> The stimuli in Barber & Carreiras carried word markers that are traditionally associated with the masculine (-o) and feminine (-a) genders respectively, and canonical plural morphology (-s).

Number and gender agreement violations in both noun-adjective (25) and determiner-noun pairs (26) yielded indistinguishable N400s, a component that is traditionally associated with difficulty in lexical—as opposed to syntactic—integration. Interestingly, some LAN-like effects were also found for both number and gender disagreement in determiner-noun pairs (26). Barber & Carreiras account for this effect by arguing that, unlike noun-adjective pairs, determiner-noun pairs constitute a syntactic structure. The only difference that the authors found in the processing of number and gender concerned a component (or family of components) that is associated with the detection of unexpected stimuli, the P3, whose latency was longer for gender than number agreement violations. Barber & Carreiras interpret these findings as evidence that repair and reanalysis are costlier for gender than number. Based on Friederici’s proposal (2002) that reanalysis and repair are reflected in the P600, the authors then compared number and gender agreement violations in sentential contexts, with violations either in initial (27) or in middle position, as in (28).<sup>17</sup>

(27)

**Grammatical**

- a. el                      piano                      estaba viejo y    desafinado.  
     the-MASC-SG piano-MASC-SG was old and off-key  
     “the piano was old and off-key”

**Number Violation**

- b. los                      \*piano                      estaba viejo y    desafinado.  
     the-MASC-PL piano-MASC-SG was old and off-key  
     Intended meaning: “the piano was old and off-key”

**Gender Violation**

- c. la                      \*piano                      estaba viejo y    desafinado.  
     the-FEM-SG piano-MASC-SG was old and off-key  
     Intended meaning: “the piano was old and off-key”

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<sup>17</sup> The number of participants in Barber & Carreiras (2005) was 24.



(28)

**Grammatical**

- a. el faro es alto y luminoso.  
the lighthouse-MASC-SG is high-MASC-SG and bright  
“the lighthouse is high and bright”

**Number Violation**

- b. el faro es \*altos y luminoso.  
the lighthouse-MASC-SG is high-MASC-PL and bright  
Intended meaning: “the lighthouse is high and bright”

**Gender Violation**

- c. el faro es \*alta y luminoso.  
the lighthouse-MASC-SG is high-FEM-SG and bright  
Intended meaning: “the lighthouse is high and bright”

(Adapted from Barber & Carreiras, 2005, p. 151)

Number and gender agreement violations revealed equal LANs in both initial (27) and middle (28) position. A P600 was also found for both violation types in both initial and middle position. However, the second phase of the P600 (700-900ms) showed greater amplitude for gender than for number agreement violations, which the authors interpret as convergent evidence that reanalysis of gender is costlier. These results ultimately support Faussart et al.’s hypothesis (1999) that—unlike number—gender is essentially a lexical feature. Thus, when presented with gender mismatches, subjects must go back to the lexical entry of a noun, check its gender information and, then, perform reanalysis and repair.

As mentioned in the introduction, some important factors regarding the stimuli in Barber & Carreiras must be taken into consideration. First of all, violations in initial position, as in (27), were always noticeable on nouns, whereas those in middle position, as in (28), were always noticeable on adjectives. Secondly, violations in initial position occurred within the same syntactic unit, whereas those in middle position occurred across phrases. Crucially, the ERP effects found in middle position were greater than

those in initial position, which the authors interpret as evidence that violations across phrases require the allocation of greater resources than violations within the same syntactic unit. This is one of the hypotheses tested in the current study.

Another ERP study by Barber & Carreiras (2003) on the processing of number and gender agreement between nouns and adjectives in Spanish obtained very similar results. The purpose of this study was also to put to the test the contradictory findings from previous behavioral studies suggesting that different types of agreement are similar (Lukatela et al., 1987; Colé & Segui, 1994) or different processes (Faussart et al., 1999). The study encompassed number and gender agreement violations, as in (29b) and (29c) respectively, as well as combined number-gender violations (29d).<sup>18</sup> As a control, the authors included a grammatical condition using nouns and adjectives without canonical word markers to ensure that participants were not just mapping the word markers of the nouns onto the adjectives (29e).

(29)

**Grammatical**

- a. faro                                      alto  
lighthouse-MASC-SG    high-MASC-SG  
“high lighthouse”

**Number Violation**

- b. faro                                      \*altos  
lighthouse-MASC-SG    high-MASC-PL  
Intended meaning: “high lighthouse”

**Gender Violation**

- c. faro                                      \*alta  
lighthouse-MASC-SG    high-FEM-SG  
Intended meaning: “high lighthouse”

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<sup>18</sup> In all three conditions, mismatches always became noticeable on adjectives. In addition, none of the nouns in the study provided a semantic gender clue and they all exhibited canonical gender and number morphology, which was also true for the adjectives.

### Combined Violation

- d. faro   \*altas  
lighthouse-MASC-SG    high-FEM-PL  
Intended meaning: “high lighthouse”

### Control

- e. poesía   triste  
poetry-FEM-SG       sad-FEM-SG  
“sad poetry”

(Adapted from Barber & Carreiras, 2003, p. 470)

All violation types elicited a canonical N400 component, which, crucially, did not differ across conditions. As mentioned earlier, the N400 is traditionally associated with difficulty in lexical integration. Therefore, Barber & Carreiras account for the presence of this component in agreement mismatches—and for the lack of a LAN or a P600—by arguing that their stimuli did not constitute minimal syntactic units. Therefore—they argue—the integration of nouns and adjectives in their study was processed at the lexical level. Interestingly, a comparison of the control condition (29e) to the grammatical word pairs in the experiment revealed no effect of morphological canonicity, suggesting that the N400 elicited by the agreement violations was not due to the failure to map phonological or orthographic forms from nouns to adjectives.

In addition to the N400, a P3 was also found for all conditions, including grammatical word pairs.<sup>19</sup> Contrary to the N400, which was unaffected by agreement type, Barber & Carreiras found that the P3 peaked later for number and gender agreement violations than for grammatical sentences. Moreover, gender agreement violations peaked latest, which the authors interpret as support for Faussart et al.’s model. A problem with this interpretation is that the P3 for combined violations peaked earlier than the P3 for number mismatches alone and gender violations alone.

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<sup>19</sup> This is unexpected, given the traditional interpretation of the P3.

Another study, by Wicha, Moreno, & Kutas (2004), investigating the interaction between gender agreement and semantic congruity in online visual sentence processing found relatively similar effects to those reported by Barber & Carreiras (2005). The stimuli in Wicha et al. consisted of short stories in Spanish biasing participants towards one particular word. The semantic fit of that word was then manipulated (30a vs. 30b), as was the gender of the preceding determiner (30a vs. 30c; agreeing words are underlined):

(30)

**Grammatical/Congruous**

- a. el príncipe sabía que cuando su padre muriera podría al fin  
 the prince knew that when his father died he-could finally

ponerse la corona  
 wear the-FEM-SG crown-FEM-SG

“the prince knew that when his father died he would finally be able to wear the crown”

**Grammatical/Incongruous**

- b. el príncipe sabía que cuando su padre muriera podría al fin  
 the prince knew that when his father died he-could finally

ponerse la maleta  
 wear the-FEM-SG suitcase-FEM-SG

“the prince knew that when his father died he would finally be able to wear the suitcase”

**Gender Violation/Congruous**

- c. el príncipe sabía que cuando su padre muriera podría al fin  
 the prince knew that when his father died he-could finally

ponerse el \*corona  
 wear the-MASC-SG crown-FEM-SG

Intended meaning: “the prince knew that when his father died he would finally be able to wear the crown”

### Gender Violation/Incongruous

d. el príncipe sabía que cuando su padre muriera podría al fin  
the prince knew that when his father died he-could finally

ponerse el \*maleta  
wear the-MASC-SG suitcase-FEM-SG

Intended meaning: “the prince knew that when his father died he would finally be able to wear the suitcase”

(Adapted from Wicha et al., 2004, p. 1286)

Gender agreement violations alone (as in 30c) and collapsed over semantic congruity (30c and 30d) yielded a posteriorly distributed P600 that was slightly more prominent over the right hemisphere. Unlike the experiment in Barber & Carreiras (2005) investigating the processing of number and gender agreement in sentential contexts, no LAN was reported by Wicha and colleagues, who also used sentential contexts. This suggests that the nature of the LAN is more complicated than initially stated by Friederici (2002) and that this component cannot simply reflect the detection of a morphosyntactic mismatch. Besides these gender effects, the authors also found a main effect of semantic fit (an N400 for violations of semantic fit) and an interaction between semantic fit and gender agreement, which resulted in a more negative N400 and a less positive P600 for sentences containing both a semantic anomaly and a gender agreement violation (as in 30d). Ultimately, the study by Wicha et al. provides evidence for an interaction between semantics and morphosyntax at some stage between 400 and 800ms. Although the design by Wicha et al. is different from the one in the present study, which does not manipulate semantic fit, it is important to keep in mind that semantic incongruity can affect the parser’s sensitivity to a gender agreement violation

(as shown by a less positive P600 for combined vs. single gender agreement violations).<sup>20</sup>

Finally, gender agreement mismatches also yielded a positive wave between 500 and 700ms at the article preceding the critical word, a point where there was still no outright syntactic violation. Wicha et al. interpret this finding as evidence that readers anticipate not only words, but also their gender value. Another interpretation of their results is that, when a syntactic—as opposed to lexical—expectation is violated, the result is a positive deflection resembling the P600, instead of an N400, which is the component that is traditionally associated with unpredicted stimuli.

Using a very similar design, Wicha, Bates, Moreno, & Kutas (2003) conducted an earlier study investigating whether listeners anticipate the syntactic gender of a noun during auditory sentence processing, even when the noun is not present in the sentence. In their study, subjects listened to short stories in Spanish biasing them towards one particular noun. Each critical noun had been replaced with a line drawing, which could be semantically expected or unexpected. In addition, the gender of the article preceding the drawing was also manipulated. Crucially, violations of gender agreement between a determiner and a drawing (where violations became noticeable), alone and collapsed over semantic fit, yielded a negativity with a later latency (500-700ms) and a different distribution than the canonical N400. The authors interpret these results as evidence that listeners retrieve the gender of a noun even in the absence of the noun itself (and its gender morphemes or markers). What is most interesting about the results of the Wicha et al. studies is that gender agreement violations yielded different effects depending on whether the mismatch involved non-linguistic stimuli (a negativity between 500-700ms)

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<sup>20</sup> This is one of the reasons why it was decided that the present study would focus on the processing of non-semantic gender.

or linguistic stimuli (P600), providing evidence against the hypothesis that the P600 is a non-language-specific component associated with unexpected stimuli (a member of the P3 family), as both semantically incongruent nouns and drawings were equally unexpected.

Finally, Martín-Loeches, Nigbur, Casado, Hohlfeld, & Sommer (2006) also examined the electrophysiological processing of number and gender agreement in Spanish, in a study analyzing the time course of syntax and semantics during sentence processing. As was the case with Wicha et al. (2004), the Martín-Loeches et al. study examines whether (and when) semantic fit and syntactic agreement interact during visual sentence processing. The stimuli in their study consisted of sentences including adjacent nouns and adjectives that disagreed in number (31b), gender (31c) or both (31d). In the examples below, agreeing words are underlined:

(31)

**Grammatical/Congruous**

a. el sentimiento                    profundo                    emociona  
 the feeling-MASC-SG    deep-MASC-SG    moves  
 “the deep feeling moves”

**Number Violation/Congruous**

b. el sentimiento                    \*profundos                    emociona  
 the feeling-MASC-SG    deep-MASC-PL    moves  
 Intended meaning: “the deep feeling moves”

**Gender Violation/Congruous**

c. el sentimiento                    \*profunda                    emociona  
 the feeling-MASC-SG    deep-FEM-SG    moves  
 Intended meaning: “the deep feeling moves”

**Combined Violation/Congruous**

d. el sentimiento                    \*profundas                    emociona  
 the feeling-MASC-SG    deep-FEM-PL    moves  
 Intended meaning: “the deep feeling moves”

(Adapted from Martín Loeches et al., 2006, p. 182)

In addition, the semantic fit between the noun and the adjective was also manipulated for all of the conditions in (31a-d). Below is an example of one of the incongruous conditions:

(32)

**Grammatical/Incongruous**

- a. el sentimiento            peludo            emociona  
the feeling-MASC-SG    hairy-MASC-SG    moves  
“the hairy feeling moves”

(Adapted from Martín Loeches et al., 2006, p. 182)

Agreement violations elicited a non-significant LAN and a P600 that peaked 800ms post-stimulus presentation. No significant differences between agreement types are reported. For their part, semantic violations elicited a canonical N400 and a small P600. Crucially, combined violations elicited an N400 that was identical to the one found for semantic violations alone and a P600 that was smaller than the one reported for agreement violations alone. Martín-Loeches et al. interpret these results as evidence that semantics can influence the processing of agreement (as reflected in a smaller P600 for combined violations than for simple agreement mismatches alone), but not vice-versa (as indicated by the identical N400s in semantic and combined violations). The results by Martín-Loeches et al. largely support those by Wicha et al. (2004) in that they both found a P600 and failed to find a LAN for agreement violations in Spanish sentences.<sup>21</sup>

In sum, studies investigating the electrophysiological processing of number and gender agreement in Spanish sentences have systematically reported P600 effects. As to the LAN, the Barber & Carreiras study (2005) is the only one that has reported this effect so far. In the next section, the studies researching the electrophysiological processing of number and gender agreement in other languages will be briefly reviewed.

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<sup>21</sup> The Martín-Loeches et al. (2006) and Wicha et al. (2004) studies also converge in that they both found an interaction between semantics and morphosyntax, although the nature of the interaction differed in each study.



## 4.1.2. ERP Studies on the Processing of Agreement in other Languages

### 4.1.2.1. English

Based on the observation that number is sometimes processed as a purely syntactic feature (e.g., a collective noun like *family* can trigger singular agreement on the verb, as in *Her family is one aunt about a thousand years old*) and others as a semantic feature (e.g. *My family have been prominent, well-to-do people in this Middle Western city for three generations*), Osterhout & Mobley (1995) conducted a study investigating whether features like number and gender, which in English have consequences for both the syntax and the semantics, are associated with syntactic or semantic ERP responses.<sup>22</sup> The participants in Osterhout & Mobley performed an acceptability judgment task on sentences with a subject-verb agreement violation, as in (33b), a number agreement violation between a reflexive and its antecedent, as in (34b), and a gender mismatch between a reflexive and its antecedent, as in (35b):

(33)

#### **Subject-Verb Agreement Violation**

- a. The elected officials hope to succeed.
- b. The elected officials \*hopes to succeed.

(34)

#### **Number Agreement Violation (Reflexive-Antecedent)**

- a. The hungry guests helped themselves to the food.
- b. The hungry guests helped \*himself to the food.

(35)

#### **Gender Agreement Violation (Reflexive-Antecedent)**

- a. The successful woman congratulated herself on the promotion.
- b. The successful woman congratulated \*himself on the promotion.

(Adapted from Osterhout & Mobley, 1995, p. 742)

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<sup>22</sup> Examples provided by Osterhout & Mobley (1995, 2a-b), originally from *The Great Gatsby* (Fitzgerald, 1925).

All violation types elicited a P600, which is consistent with other studies investigating the neurophysiological processing of agreement. Osterhout & Mobley interpret these results as evidence that number and gender agreement are processed syntactically, rather than semantically. Furthermore, in a second experiment testing the effects of semantic violations, as in (36b), only an N400 was reported, suggesting that the elicitation of the P600 for (33b-35b) could not be accounted for by the unexpectedness of the agreement violations (in line with the Wicha et al. studies, but see Coulson et al., 1998), because semantic violations were equally unexpected.

(36)

**Semantic Violation**

- a. The boat sailed down the river and sank during the storm.
- b. The boat sailed down the river and \*barked during the storm.

(Adapted from Osterhout & Mobley, 1995, p. 749)

Finally, subject-verb number agreement violations (33b) also yielded a negative deflection between 300-500ms with a left anterior and temporal distribution. The authors argue that this last component fits within the morphology of the N400, but exhibits a non-canonical distribution due to the presence of the later P600.<sup>23</sup> Given that this left anterior negativity was not elicited in a following experiment using the same stimuli, the authors reserve conclusions about it.

A problem with Osterhout & Mobley is that, when the experiment was replicated with the same stimuli but without a behavioral task, only the subject-verb agreement violation condition elicited a P600. For their part, number and gender agreement violations between reflexives and antecedents failed to yield any significant effects,

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<sup>23</sup> It should be noted that this negativity is actually more similar to the Left Anterior Negativity.

indicating that the P600 found for this type of agreement violation might be related to the effects of the Acceptability Judgment Task.<sup>24</sup>

In a subsequent study, Osterhout, Bersick, & McLaughlin (1997) examined gender agreement violations between reflexives and antecedents when the referents were unequivocally masculine or feminine, as in (37), and when the referents were stereotypically masculine or feminine, as in (38):

(37)

**Definitional Gender Violation**

- a. The pope enjoyed himself in Colorado.
- b. The pope enjoyed \*herself in Colorado.

(38)

**Stereotypical Gender Violation**

- a. The popular babysitter found herself overcommitted on Fridays.
- b. The popular babysitter found himself overcommitted on Fridays.

(Adapted from Osterhout et al., 1997, p. 284)

Violations of both definitional and stereotypical gender yielded similar P600 effects, although differences in amplitude were observed, the P600 for outright gender agreement violations (37) being greater than for violations of stereotypical gender. What is most significant about this study is that agreement involving nouns without an inherent gender feature (e.g., *babysitter*, *mechanic*) still yielded what is assumed to be a syntactic ERP component (P600), as opposed to a component that is more related to lexical or pragmatic integration, like the N400. In addition, Osterhout et al. interpret the differences in the amplitude of the P600s for definitional and stereotypical gender agreement violations as evidence that the P600 is related to syntactic repair rather than syntactic anomaly detection. Given that violations of definitional (but not stereotypical)

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<sup>24</sup> However, this is in contradiction with a previous study by Hagoort, Brown, & Groothusen (1993) where a P600 was reported for agreement violations in Dutch in an experiment with no behavioral task.

gender agreement are actual ungrammaticalities, it is reasonable to hypothesize that syntactic recovery should be costlier and yield a larger P600.

#### 4.1.2.2. Dutch

Hagoort & Brown (1999) conducted a similar study investigating whether gender agreement violations in visual sentence processing elicited syntax-related (e.g., a P600) or semantics-related (e.g., an N400) ERP components. Contrary to Osterhout & Mobley (1995), Hagoort & Brown examined the processing of gender in Dutch, a language where there is no direct correspondence between biological gender and the two values of its gender system (common and neuter). The stimuli in Hagoort & Brown manipulated the gender congruency between a determiner and a noun either at the beginning of a sentence (subject DP) or in final position (object DP). In both cases, the determiner and the noun were separated by an adjective not inflected for gender, and the violations became noticeable on the nouns, where the gender feature is interpretable. An example of their stimuli is provided in (39) below:

(39)

##### **Grammatical**

- a. De kapotte paraplu staat in de garage.  
the-COM broken umbrella-COM is in the garage.  
“The broken umbrella is in the garage”

##### **Gender Violation**

- b. Het kapotte \*paraplu staat in de garage  
the-NEUT broken umbrella-COM is in the garage.  
Intended meaning: “The broken umbrella is in the garage”

(Adapted from Hagoort & Brown, 1999, p. 718)

Gender agreement violations in both initial and final position elicited a long-lasting P600 with a rather canonical topographical distribution (posterior and bilateral), providing converging evidence that gender is processed syntactically rather than semantically (in line with Osterhout & Mobley, 1995). An N400 was also found, but only for gender agreement violations in final position, an effect that the authors assign to sentence wrap-up effects, ungrammatical sentences being more difficult to wrap-up than grammatical ones. Contrary to Barber & Carreiras (2005), Hagoort & Brown did not report a Left Anterior Negativity, which is consistent with the results of many other studies on gender agreement that failed to report this component. Given that the LAN is thought to reflect feature checking (Friederici, 2002), Hagoort & Brown argue that the absence of this component in their study may be due to the fact that Dutch nouns are specified for gender but do not exhibit any gender morphology. For that reason, they predict no morphological feature checking between the agreeing elements in their stimuli and, hence, no LAN.

In a subsequent study, Hagoort (2003) compared the neurophysiological effects of number and gender agreement violations in semantically legal and deviant sentences. Ultimately, the aim of Hagoort's study was to investigate potential interactions between syntax and semantics during sentence processing. The stimuli in Hagoort included gender and number agreement violations where the semantic fit of the sentence had been manipulated, as in (40) and (41), respectively. In all cases, the violation could be located in the middle or at the end of the sentence:

(40)

**Grammatical/Congruous**

- a. De kapotte paraplu staat in de garage.  
 the-COM broken umbrella-COM is in the garage.  
 "The broken umbrella is in the garage"

### Gender Violation/Congruous

- b. Het kapotte \*paraplu staat in de garage  
the-NEUT broken umbrella-COM is in the garage.  
Intended meaning: “The broken umbrella is in the garage”

### Grammatical/Incongruous

- c. De eerlijke paraplu staat in de garage.  
the-COM honest umbrella-COM is in the garage.  
“The honest umbrella is in the garage”

### Gender Violation/Incongruous

- d. Het eerlijke \*paraplu staat in de garage  
the-NEUT honest umbrella-COM is in the garage.  
Intended meaning: “The honest umbrella is in the garage”

(41)

### Grammatical/Congruous

- a. De bekwame vaklieden zien de kwaliteit  
the-PL skilled craftsmen-PL appreciate the quality

van het produkt.  
of the product.

“The skilled craftsmen appreciate the quality of the product.”

### Number Violation/Congruous

- b. Het bekwame \*vaklieden zien de kwaliteit  
the-SG skilled craftsmen-PL appreciate the quality

van het produkt.  
of the product.

Intended meaning: “The skilled craftsmen appreciate the quality of the product.”

### Grammatical/Incongruous

- c. De zoute vaklieden zien de kwaliteit  
the-PL salty craftsmen-PL appreciate the quality

van het produkt.  
of the product.

“The salty craftsmen appreciate the quality of the product.”

### Number Violation/Incongruous

- d. Het zoute \*vaklieden zien de kwaliteit  
the-SG salty craftsmen-PL appreciate the quality

van het produkt.  
of the product.

Intended meaning: “The salty craftsmen appreciate the quality of the product.”

(Adapted from Hagoort, 2003, p. 886)

Agreement violations (40b and 41b) yielded a canonical P600, which was preceded by a negative deflection similar to the N400 when the violation was in final position (probably due to wrap-up effects).<sup>25</sup> For their part, semantic violations (40c and 41c) elicited the expected component for violations of semantic fit, the N400. Crucially, combined violations (40d and 41d) resulted in a greater N400 than the one found for semantic violations alone and a P600 that was very similar to the P600 found for agreement violations alone. Hagoort interprets these results as evidence that agreement (syntax) is independent from semantics (no additive effects in the syntax-related P600), but not vice-versa (additive effects in the semantics-related N400).

#### 4.1.2.3. Hebrew

For their part, Deutsch & Bentin (2001) investigated the extent to which syntactic gender is constrained by biological gender in Hebrew, a language where—as in Spanish—semantic gender is highly correlated with the two values of its syntactic gender system (masculine and feminine). The authors point out that some of the previous studies investigating gender agreement, both behaviorally and neurophysiologically, have provided contradictory results on the matter, based on whether the working language was English (a morphologically impoverished language)

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<sup>25</sup> Hagoort does not discard the possibility that this negativity is actually a LAN.

or languages with richer morphology (e.g., Spanish, French, or Dutch). Hebrew being a language with very rich morphology, if semantic gender has an impact on syntactic gender agreement, agreement mismatches involving semantic gender should modulate both the P600 and the N400.

The stimuli in Deutsch & Bentin consisted of sentences manipulating the gender congruency between the subject noun of an embedded clause and its verb (42a and 42c vs. 42b and 42d). The target verb (the critical word) was always masculine singular, which in Hebrew is morphologically unmarked. In addition, the animacy of the subject was also manipulated (42a and 42b vs. 42c and 42d). Below is a sample of the stimuli in Deutsch & Bentin, transliterated into English:

(42)

**Grammatical/Animate**

- a. The woman saw that the boy-MASC-SG had fallen-MASC-SG into the pond.

**Gender Violation/Animate**

- b. The woman saw that the girl-FEM-SG had \*fallen-MASC-SG into the pond.

**Grammatical/Inanimate**

- c. The woman saw that the diamond-MASC-SG had fallen-MASC-SG into the pond.

**Gender Violation/Inanimate**

- d. The woman saw that the necklace-FEM-SG had \*fallen-MASC-SG into the pond.

(Adapted from Deutsch & Bentin, 2001, p. 208)

The authors also included a condition where all target verbs were pluralized and, therefore, morphologically marked, as in (43):



(43)

**Grammatical/Animate**

- a. I enjoyed seeing how the actors-MASC-PL were enchanting-MASC-PL the tired audience.

**Gender Violation/Animate**

- b. I enjoyed seeing how the actresses-FEM-PL were \*enchanting-MASC-PL the tired audience.

**Grammatical/Inanimate**

- c. I enjoyed seeing how the movies-MASC-PL were enchanting-MASC-PL the tired audience.

**Gender Violation/Inanimate**

- d. I enjoyed seeing how the pictures-FEM-PL were \*enchanting-MASC-PL the tired audience.

(Adapted from Deutsch & Bentin, 2001, p. 208)

Gender agreement violations collapsed over animacy and markedness (42b, 42d, 43b, and 43d) yielded an early left negativity, a P600, and an N400. The early negativity, which was unaffected by either markedness or animacy, lacked the canonical morphology of the ELAN. Thus, Deutsch & Bentin reserve conclusions about its presence in their results. As predicted, the N400 was modulated by animacy (but not by markedness), showing that semantic gender may actually interact with syntactic gender. Finally, the P600 was modulated by markedness (but not by animacy), providing further evidence that this component is involved in morphosyntactic processing.

**4.1.2.4. German**

Schmitt, Lamers, & Münte (2002) conducted a similar study focusing on cases where there is a conflict between the syntactic gender of a noun and the biological gender of the entity it refers to (e.g., neuter *das Bübchen*, “the little boy” vs. masculine *der Bub* “the boy”). Ultimately, the purpose of their study was to determine what type of

information (syntactic vs. semantic) is privileged during sentence processing when the parser runs into conflicting cues. The stimuli in Schmitt et al. encompassed German sentences with two coordinated clauses. The subject nouns in the first clause were either non-diminutives, for which there was always a direct correspondence between syntactic and biological gender, or diminutives, which are always neuter in German and, therefore, cannot reflect the biological gender of the entity they refer to. For its part, the subject of the second clause was always a pronoun whose gender value was manipulated. An example of the sentences with non-diminutive subjects in Schmitt et al. is provided in (44a-c):

(44)

**+Syntactic +Semantic Agreement**

- a. Der Bub will schlafen und darum schaltet er  
 the boy-MASC wants sleep and therefore switches he-MASC  
 eine Lampe aus  
 a lamp off

“The boy wants to sleep and therefore switches a light off.”

**-Syntactic/No biological gender**

- b. Der Bub will schlafen und darum schaltet \*es  
 the boy-MASC wants sleep and therefore switches it-NEUT  
 eine Lampe aus  
 a lamp off

Intended meaning: “The boy wants to sleep and therefore switches a light off.”

**-Syntactic -Semantic Agreement**

- c. Der Bub will schlafen und darum schaltet \*sie  
 the boy-MASC wants sleep and therefore switches she-FEM  
 eine Lampe aus  
 a lamp off

Intended meaning: “The boy wants to sleep and therefore switches a light off.”

An example of the conditions with a diminutive subject is provided in (45a-c):

(45)

**+Syntactic -Semantic Agreement**

- a. Das Bübchen will schlafen und darum schaltet es  
the little-boy-NEUT wants sleep and therefore switches it-NEUT  
  
eine Lampe aus  
a lamp off

“The little boy wants to sleep and therefore switches a light off.”

**-Syntactic +Semantic Agreement**

- b. Das Bübchen will schlafen und darum schaltet er  
the little-boy-NEUT wants sleep and therefore switches he-MASC  
  
eine Lampe aus  
a lamp off

Intended meaning: “The little boy wants to sleep and therefore switches a light off.”

**-Syntactic -Semantic Agreement**

- c. Das Bübchen will schlafen und darum schaltet \*sie  
the little-boy-NEUT wants sleep and therefore switches she-FEM  
  
eine Lampe aus  
a lamp off

Intended meaning: “The little boy wants to sleep and therefore switches a light off.”

(Adapted from Schmitt et al., 2002, p. 335)

Results showed that, for non diminutives (as in 44), the parser relies on both semantic and syntactic information to compute agreement. In other words, agreement violations that involved both syntactic and biological gender (44c) yielded an N400-P600 complex. By contrast, agreement violations that involved purely syntactic gender (44b) only elicited a P600. As far as diminutives are concerned, agreement violations yielded a P600, but not an N400. The results by Schmitt et al. are in line with Deutsch

& Bentin (2001) in that they both report N400 effects for violations of semantic gender (but see Osterhout & Mobley, 1995).

In another German study investigating the time course of syntax and semantics during sentence comprehension, Gunter, Friederici, & Schriefers (2000) examined the interaction (or lack thereof) between semantic congruity and syntactic gender agreement in visual sentence processing. The stimuli in their study consisted of German sentences manipulating both determiner-noun gender congruency (46a vs. 46b) and the semantic fit between a verb and its object (46a vs. 47a). In both cases, the violation became noticeable on the noun:

(46)

**Grammatical/Congruous**

- a. Sie bereist das Land auf einem Kraftigen Camel  
she travels the-NEUT land-NEUT on a strong camel  
“She travels the land on a strong camel”

**Gender Agreement Violation/Congruous**

- b. Sie bereist den \*Land auf einem Kraftigen Camel  
she travels the-MASC land-NEUT on a strong camel  
Intended meaning: “She travels the land on a strong camel”

(47)

**Grammatical/Incongruous**

- a. Sie befährt das \*Land auf einem Kraftigen Camel  
she drives the-NEUT land-NEUT on a strong camel  
“She drives the land on a strong camel”

**Gender Agreement Violation/Incongruous**

- b. Sie befährt den \*Land auf einem Kraftigen Camel  
she drives the-MASC land-NEUT on a strong camel  
Intended meaning: “She drives the land on a strong camel”

(Adapted from Gunter et al., 2000, p. 559)

Gender agreement violations collapsed over semantic fit (46b and 47b) yielded a LAN and a P600, both of which exhibited a canonical distribution. For their part, semantic incongruities elicited a broadly distributed N400. Most importantly, neither the LAN nor the N400 were affected by the presence of a double violation (47b), suggesting that, initially, syntax and semantics run independently. However, the P600 for double violations (47b) showed a decrease in amplitude and a delayed onset, which Gunter et al. interpret as evidence that semantics affects syntax during the reprocessing stage that the P600 is assumed to index. The results by Gunter et al. largely support those by Wicha et al. (2004), who also reported a less positive P600 for combined (gender agreement and semantic) vs. single gender agreement violations.

Another ERP study making use of morphosyntactic violations to test models of sentence processing was conducted by Rossi, Gugler, Hahne, & Friederici (2005).<sup>26</sup> Rossi et al. investigate whether phrase structure building, which is known to precede and operate independently from semantics (i.e., Frisch, Hahne, & Friederici, 2004), also precedes other syntactic processes like agreement or case assignment. Rossi et al. address this question by comparing the ERP effects elicited by phrase structure violations (48b), subject-verb agreement mismatches (48c), and combined violations (48d). The rationale behind this comparison is that, if phrase structure building precedes agreement, then a phrase structure violation should block agreement.

(48)

**Control**

- a. Der Junge im Kindergarten singt ein Lied.  
the boy-3<sup>rd</sup>-SG in-the kindergarten sings-3<sup>rd</sup>-SG a song  
“The boy in the kindergarten sings a song”

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<sup>26</sup> Unlike most other studies, Rossi et al. (2005) was an auditory study.

### Phrase Structure Violations

- b. Der Junge im \*singt ein Lied.  
the boy in-the sings a song  
“The boy in the sings a song”

### Agreement Violation

- c. Der Junge im Kindergarten \*singt ein Lied.  
the boy-3<sup>rd</sup>-SG in-the kindergarten sing-2<sup>nd</sup>-SG a song  
Intended meaning: “The boy in the kindergarten sings a song”

### Combined Violation

- d. Der Junge im \*singt ein Lied.  
the boy-3<sup>rd</sup>-SG in-the sing-2<sup>nd</sup>-SG a song  
“The boy in the sing a song”

(Adapted from Rossi et al., 2005, p. 229)

Agreement violations alone, as in (48c), yielded a late LAN (450-650ms) and a P600. Phrase structure violations alone (48b) elicited an ELAN and a P600. Crucially, combined violations (48d) elicited the same effects as phrase structure violations: an ELAN and a P600. The absence of the LAN in combined violations is taken by Rossi et al. as evidence that phrase structure building precedes agreement (morphosyntactic processing).<sup>27</sup> Rossi et al. point out that the P600 for combined violations showed a decrease in amplitude with respect to both the P600 for phrase structure violations and the P600 for agreement violations, which they interpret as evidence for a late interaction between phrase structure building and agreement. In line with Barber & Carreiras (2005), Rossi et al. also hypothesize that the greater amplitude of the P600 for agreement violations might be due to the presence of more intervening material between the agreeing elements.

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<sup>27</sup> Therefore, when the parser fails to correctly assign a phrase structure to the incoming input, agreement is not computed and no LAN is elicited.

#### 4.1.2.5. Italian

Another study using the ERP methodology to investigate the time course of syntax and semantics during visual sentence processing is De Vincenzi, Job, Di Matteo, Angrilli, Penolazzi, Ciccarelli, & Vespignani (2003). The stimuli in De Vincenzi et al. encompassed subject-verb number agreement violations (49) (agreeing words are underlined) and semantic violations (50) (critical word is underlined). In both cases, violations were located in the middle of the sentence.

(49)

##### **Grammatical**

- a. La segretaria bionda chiama per un appuntamento.  
the secretary-3<sup>rd</sup>-SG blonde calls-3<sup>rd</sup>-SG for an appointment  
“The blonde secretary calls for an appointment.”

##### **Subject-Verb Number Agreement Violation**

- b. La segretaria bionda \*chiamano per un appuntamento.  
the secretary-3<sup>rd</sup>-SG blonde calls-3<sup>rd</sup>-PL for an appointment  
Intended meaning: “The blonde secretary calls for an appointment.”

(50)

##### **Congruous**

- a. La bambina spaventata fugge veloce davanti al cacciatore.  
the baby fearful escapes quickly in-front-of-the hunter  
“The fearful baby escapes quickly in front of the hunter.”

##### **Incongruous**

- b. La bambina spaventata \*piove veloce davanti al cacciatore.  
the baby fearful rains quickly in-front-of-the hunter  
“The fearful baby rains quickly in front of the hunter.”

(Adapted from De Vincenzi et al., 2003, p. 292-293)

Number agreement violations resulted in a LAN (350-450ms) and a P600, which is consistent with Barber & Carreiras (2005), Gunter et al. (2000), and Rossi et al. (2005), and semantic violations yielded an N400. Crucially, the LAN for agreement violations peaked earlier than the N400, even though the agreement mismatch became noticeable

on a suffix and the semantic violation, on the root of the verb. The authors interpret these findings as evidence that agreement precedes semantic processing (as posited by Friederici's model).

Finally, Molinaro, Vespignani, & Job (2008) compared the ERP effects associated with violations of phonotactic constraints and violations of syntactic gender agreement. In Italian, the masculine definite determiner, *il*, is realized as *lo* when preceding words that begin with an alveolar affricate, certain consonant clusters, a palatal glide, a palatal nasal, or a voiceless palatal fricative, as in *scialle* "shawl" (51), orthographically represented as *sc* (Russi, 2006). An example of the phonotactic constraint violation condition in Molinaro et al. can be found in (51b), relative to (51a). An example of the gender agreement violations can be found in (51c), relative to (51a).

(51)

**Grammatical/No Phonotactic Violation**

- a. La vecchina con lo scialle cammina lentamente...  
the old-lady with the-MASC shawl-MASC walks slowly  
"The old woman with the shawl walks slowly..."

**Grammatical/Phonotactic violation**

- b. La vecchina con il \*scialle cammina lentamente...  
the old-woman with the-MASC shawl-MASC walks slowly  
Intended meaning: "The old woman with the shawl walks slowly..."

**Ungrammatical/No Phonotactic Violation**

- c. La vecchina con la \*scialle cammina lentamente...  
the old-woman with the-FEM shawl-MASC walks slowly  
Intended meaning: "The old woman with the shawl walks slowly..."

(Adapted from Molinaro et al., 2008, p. 164)

Both violation types (51b and 51c) yielded an almost identical LAN, and a P600. Crucially, the second phase of the P600 (700-900 ms) was significantly greater for violations of phonotactic constraints (51b) than for gender agreement violations (51c). Molinaro et al. argue that, in line with Barber & Carreiras (2005), their results support



Faussart et al.'s model of lexical processing, according to which, reanalysis is costlier when the parser has to go back to the earlier stages of lexical processing. In Molinaro et al., phonotactic probabilities are processed in the pre-lexical stage, while gender is processed during lexical identification. Thus, following Faussart et al., having to go back to the pre-lexical stage to repair a phonological violation yields a larger P600.

The general conclusion that can be drawn from the aforementioned ERP studies investigating agreement in languages other than Spanish is that purely syntactic agreement violations systematically elicit a P600, and sometimes—but, crucially, not always—a Left Anterior Negativity. These two ERP components being associated with morphosyntactic processing, it appears that agreement mismatches are processed syntactically. In this respect, it must be mentioned that the only studies reporting N400-effects for number or gender mismatches used violations at the end of the sentence, a context where the N400 is usually found, even for grammatical sentences. Finally, violations of both syntactic and semantic gender appear to modulate both the P600 and the N400 (Deutsch & Bentin, 2001; Schmitt, Lamers, & Münte, 2002), although not consistently (Osterhout & Mobley, 1995).

#### **4.2. The Effects of Syntactic Distance/Complexity on the Electrophysiological Processing of Syntactic Dependencies.**

A few studies have used event-related potentials to investigate the role of distance in the processing of syntactic dependencies (Münte et al., 1997; Gunter et al., 1997; Kaan, 2002; Vos et al., 2001). However, most of these previous studies suffer from methodological problems, such as the lack of systematic control for linear distance (the number of words between the agreeing words) and structural distance (the number of

syntactic nodes between the elements in an agreement relationship). In addition, as pointed out by Kaan (2002), the results are very diverse.

Münte et al. (1997) investigated whether the morphology of the P600 was sensitive to complexity. The P600 being a component that is associated with reprocessing (reanalysis and repair), the authors hypothesized that, if the P600 was indeed affected by complexity, the reprocessing of more complex sentences should increase the amplitude of the P600, delay its onset, and prolong its latency. In their study, where complexity is understood as the structural distance between agreeing elements, Münte et al. compared subject-verb number agreement violations in declarative sentences, as in (52), with subject-verb number agreement violations in embedded clauses, as in (53):

(52)

**Declarative: Grammatical**

- a. Der Opa            hat    zwei Maikaefer gefunden.  
the grandfather has two June-bugs found.

Sie            brummen    beim Fliegen laut  
They-PL    hum-PL    when flying loudly

“The grandfather has found two June bugs. They hum loud when flying.”

**Declarative: Subject-Verb Number Agreement Violation**

- b. Der Opa            hat    zwei Maikaefer gefunden.  
the grandfather has two June-bugs found.

Sie            \*brumt    beim Fliegen laut  
They-PL    hum-SG    when flying loudly

Intended meaning: “The grandfather has found two June bugs. They hum loud when flying.”

(53)

**Embedded: Grammatical**

- a. Zwei Maikaefer, die beim Fliegen laut brummen  
two June-bugs which-PL when flying loud hum-PL

hat der Opa gefunden  
has the grandfather found

“The grandfather has found two June bugs, which hum loud when flying.”

**Embedded: Subject-Verb Number Agreement Violation**

- b. Zwei Maikaefer, die beim Fliegen laut \*brumt  
two June-bugs which-PL when flying loud hum-SG

hat der Opa gefunden  
has the grandfather found

Intended meaning: “The grandfather has found two June bugs, which hum loud when flying.”

(Adapted from Münte et al., 1997, p. 106)

In addition, the authors included a third condition where subject-verb number agreement was also established across an embedded clause, but with the agreeing element (the verb) in final position. Number agreement violations in both conditions yielded P600 effects with the topographical distribution that is generally associated with the P600 (posterior). Crucially, the P600 for embedded clauses (53), where the distance between the agreeing elements was longer, showed greater amplitude than the P600 in the declarative sentence condition (52), irrespective of the position of the violations. Peak latency was also affected by the complexity manipulation, with the P600 for declarative sentences (52) showing the shortest latency. By contrast, no differences in peak onset were observed. Finally, number agreement violations also elicited an unreliable LAN, but only in the declarative sentence condition.

In sum, the results by Münte et al. indicate that certain aspects of the P600 (amplitude, peak latency) can indeed be taken as indexes of complexity. However, the

same cannot be said about the LAN, for which there was only a trend in the simplest of the three conditions (the declarative sentence condition). A problem with Münte et al. is that the authors do not provide a very precise account of the concept of complexity. For example, given that their stimuli used personal pronouns (i.e., *Sie* “they”) with specific antecedents (i.e., June bugs), it could be the case that complexity was also affected by the establishment of coreference between pronouns and antecedents, which in the case of German plural pronouns is done by tracking number features.<sup>28</sup> If this is the case, the subjects had to go outside of the sentence to establish coreference in the declarative sentence condition, but not in the embedded clause condition, where coreference was established across a relative clause. Another problem with Münte et al. is that, in the declarative sentence condition, coreference between the subject (i.e., *Sie*) and its antecedent (i.e., *Maikaefer* “June bugs”) was not syntactically compulsory. By contrast, the same is not true of the subject relative pronoun *die* in the embedded clause condition, which is constrained by the syntax to be coindexed with a previous antecedent.<sup>29</sup> Finally, a more concerning problem with Münte et al.’s stimuli is that there was no control for linear distance between the declarative sentence condition, where the agreeing elements were adjacent, and the embedded clause condition, where the agreeing elements were separated by three words.

The results by Münte et al. are not supported by other ERP studies investigating the effects of complexity/distance on sentence processing: Gunter, Stowe, & Mulder (1997); Kaan (2002); and Vos, Gunter, Kolk, & Mulder (2001). The study by Gunter et al. (1997) investigated the effects of syntactic complexity on ERP components that are generally assumed to index syntactic processing (mainly, the LAN and the P600). The

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<sup>28</sup> Gender is collapsed in German plural pronouns.

<sup>29</sup> In fact, the agreement violations in the declarative sentence condition could potentially be processed as grammatical. This is because the third person plural pronoun *Sie* (i.e., *Sie*-PL \**brummt*-SG) is homophonous with the third person singular feminine pronoun *sie* (*sie*-SG *brummt*-SG).

ultimate aim of their investigation was to identify syntax-specific ERPs (as opposed to more general ones), to be able to examine the time course of syntax and semantics during sentence processing and to test sentence processing models.<sup>30</sup> The stimuli in their study consisted of Dutch sentences with embedded clauses. The latter could either be adjacent to the main clause—low complexity, as in (54) below—or be inserted between two elements of the main clause so that the parser had to keep part of the clause in working memory in order to assign structure to the sentence—high complexity, as in (55). The semantic congruity and correct inflection of the last verb in the sentences (i.e., *gered*, “saved”) were then manipulated, in order to analyze possible interactions between semantics and syntax. It is important to point out that the complexity manipulation in Gunter et al. (1997) can be understood as a difference in distance between elements in a syntactic dependency: an auxiliary verb and a lexical verb.

(54)

**Low Complexity**

- a. Terwijl een grote menigte stond toe te kijken,  
while a large crowd stood by to look

werd de kleine drenkeling door de held gered  
was the small drowning-person by the hero saved

“While a large crowd stood by to look, the small drowning person was saved by the hero.”

(55)

**High Complexity**

- a. De kleine drenkeling werd door de held  
the small drowning-person was by the hero

terwijl een grote menigte stond toe te kijken gered  
while a large crowd stood by to look saved

“The small drowning person was saved by the hero, while a large crowd stood by to look.”

(Adapted from Gunter et al., 1997, p. 666)

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<sup>30</sup> The authors consider the N400 a semantics-specific component.

Syntactic violations collapsed over complexity yielded a LAN and a P600. For its part, the complexity manipulation did not affect the LAN, but it decreased the amplitude of the P600, which the authors interpret as evidence that syntactic complexity decreases the parser’s sensitivity to reanalysis. Crucially, the results by Gunter et al. are in contradiction with those by Münte et al. (1997), whose complexity manipulation increased—as opposed to decreased—the amplitude of the P600.

For her part, Kaan (2002) compared subject-verb agreement in sentences where the subject and the verb were separated by a two-word object phrase, as in (56), with sentences where the agreeing words were separated by both a two-word object phrase and a three-word adjunct, as in (57):

(56)

**Short Distance/Grammatical**

- a. de keizer            de dissident    zal            gaan verbannen  
      the emperor-SG    the dissident    will-SG    go    ban  
      “the emperor will ban the dissident...”

**Short Distance/Subject-Verb Number Agreement Violation**

- b. de keizer            de dissident    \*zullen        gaan verbannen  
      the emperor-SG    the dissident    will-PL    go    ban  
      Intended meaning: “the emperor will ban the dissident...”

(57)

**Long Distance/Grammatical**

- a. de keizer            volgens            het gerucht    de dissident  
      the emperor-SG    according-to    the rumor    the dissident  
  
      zal            gaan verbannen  
      will-SG    go    ban

“the emperor, according to the rumor, will ban the dissident...”

### Long Distance/Subject-Verb Number Violation

b. de keizer volgens het gerucht de dissident  
the emperor-SG according-to the rumor the dissident

\*zullen gaan verbannen  
will-PL go ban

“the emperor, according to the rumor, will ban the dissident...”

(Adapted from Kaan, 2002, p. 173)

Number agreement violations for both the short and long-distance conditions yielded a non-canonical LAN that was centrally distributed (as opposed to frontally) and bilateral (as opposed to left-lateralized), and a late positivity that largely resembled the P600 in terms of its topographical distribution and latency. Crucially, the left anterior negativity found in the short-distance condition did not differ from the LAN in the long-distance condition, which Kaan interprets as evidence that distance does not affect the detection of a morphosyntactic violation. As to the P600, no differences in amplitude or onset were found either between the short and long-distance conditions, which the author takes as evidence that distance has no impact on repair and integration processes.

Interestingly, the electrophysiological and behavioral results in Kaan were contradictory, with the behavioral data showing a higher accuracy rate for the short distance condition compared to the long-distance condition. This finding suggests that, at least behaviorally, distance affects the processing of agreement (at least, subject-verb agreement). In sum, bearing in mind that the experimental stimuli in Kaan confounded linear and syntactic distance—linear distance was only two words in the short-distance condition, but five words in the long distance-condition—her study ultimately suggests that neither linear nor syntactic distance affects the processing of agreement at the electrophysiological level.

Finally, the findings by Vos et al. (2001) about the effects of working memory on sentence processing differ considerably from the previous studies. Vos et al. compared subject-verb agreement violations in cases where agreement had to be computed across two conjoined sentences, as in (58), with sentences where agreement had to be established across an embedded clause, as in (59):

(58)

**Low Complexity/Grammatical**

- a. de toeristen hebben een druk programma en bezoeken het theatre  
the tourists-PL have a busy schedule and visit-PL the theatre  
“The tourists have a busy schedule and visit the theatre.”

**Low Complexity/Subject-Verb Number Agreement Violation**

- b. de toeristen hebben een druk programma en \*bezoekt het theatre  
the tourists-PL have a busy schedule and visit-SG the theatre  
Intended meaning: “The tourists have a busy schedule and visit the theatre.”

(59)

**High Complexity/Grammatical**

- a. de toeristen die een druk programma hebben bezoeken het theatre  
the tourists-PL who a busy schedule have visit-PL the theatre  
“The tourists, who have a busy schedule, visit the theatre.”

**High Complexity/Subject-Verb Number Agreement Violation**

- b. de toeristen die een druk programma hebben \*bezoekt het theatre  
the tourists-PL who a busy schedule have visit-SG the theatre  
Intended meaning: “The tourists, who have a busy schedule, visit the theatre.”

(Adapted from Vos et al., 2001, p. 46)

Crucially, the agreeing elements in both conditions were controlled for linear distance (five words). However, it must be pointed out that both conditions included another verb inflected for number between the agreeing elements (i.e., *hebben* in the examples above), which was four words away from the critical verb in the low



complexity condition (the conjoined sentences condition) but linearly adjacent to the critical verb in the more complex condition (embedded clause condition).

Number agreement violations collapsed over both conditions elicited a bilaterally distributed LAN and a canonical P600. Most importantly, the Left Anterior Negativity found in the low-complexity condition was more negative than the LAN in the high-complexity condition, which Vos et al. interpret as evidence that syntactic complexity decreases the parser's efficiency to detect agreement mismatches. Given that the critical verb in the high-complexity condition was immediately preceded by another verb providing an extra number clue, these results can reliably be taken as evidence that the processing of agreement across embedded clauses (high-complexity condition) is more taxing than across conjoined sentences (low-complexity condition). These findings go in the same direction as those by Münte et al. (1997), who reported a non-significant LAN for the simplest of the conditions in their study. However, they contrast with the results by Kaan (2002), who found that the LAN in her study was unaffected by syntactic (and linear) distance. As far as the P600 is concerned, Vos et al. report no differences in amplitude or onset between the positivity found in the low-complexity condition (58) and the P600 in the high-complexity condition (59). These results support Kaan's argument that the processes indexed by the P600, notably integration and repair, are not affected by syntactic distance. Nevertheless, they contradict Münte et al.'s and Gunter et al.'s findings that the amplitude of the P600 can be taken as a measure of syntactic complexity. The contradictory results in Vos et al. and Münte et al. are all the more paradoxical as both studies used very similar stimuli (although in different languages).

In the following two sections, the present study, which investigates the electrophysiological processing of agreement and how it is affected by syntactic distance, will be presented. As will be shown in Section 6, the design of the present study is similar to Barber & Carreiras (2005), although the current study controls for linear distance and for the syntactic category of the critical words.

## **5. The Present Study: Hypotheses and Predictions**

The present ERP study has been designed to investigate the three following questions on the processing of agreement in Spanish:

- 1) What electrophysiological effects do violations of gender and number agreement elicit when measured on a target of agreement (adjective)? What effects do they elicit when measured on an agreement trigger (noun)?
- 2) Are there any differences in the electrophysiological processing of number and gender agreement in Spanish?
- 3) Does syntactic distance affect the electrophysiological processing of agreement—regardless of agreement category—when linear distance is controlled for? Is agreement costlier when the agreeing elements are located across phrases?

As far as the first question is concerned (electrophysiological correlates of agreement violations in Spanish), the present study follows Friederici's model of auditory sentence processing (Friederici, 2002), which assumes that processing is incremental and that morphosyntactic information is processed between 300 and 500ms, right after building the phrase structure of the sentence and right before performing semantic integration. Friederici's model further assumes that, when there is failure to integrate the incoming input due to the presence of a violation, the parser will attempt to

repair that violation some time between 500 and 900ms. If Friederici's model is on the right track, we predict that both number and gender agreement violations will consistently elicit a LAN and a P600. This prediction is based upon Friederici's proposal that the LAN is associated with the detection of a morphosyntactic violation and that the P600 is an index of repair processes.<sup>31</sup>

Regarding our second research question (differences in the electrophysiological processing of number and gender agreement), our hypothesis is based on Barber & Carreiras (2005), who argue that, during lexical retrieval, gender is processed at an earlier stage than number (gender: identification stage vs. number: integration stage) and is, therefore, costlier to repair, since the parser must travel all the way back to the root of the noun to access the gender information. The late phase of the P600 being associated with repair, we predict that gender agreement violations will show greater amplitude in the late phase of the P600 than number agreement violations.

Finally, as far as the third research question is concerned (the effects of syntactic distance on the electrophysiological processing of agreement), our predictions are also based on Barber & Carreiras (2005), who argue that agreement violations are costlier to repair when the agreeing elements are located across phrases (i.e., across a VP) than when they are located within the same phrase (i.e., inside a DP), as the parser must cross a phrase boundary to check for agreement. If Barber & Carreiras' hypothesis is on the right track, our prediction is that the late phase of the P600 (an index of repair) should display greater amplitude for across-phrase violations than for within-phrase violations.<sup>32</sup>

These research questions are addressed in a set of three experiments that will be described in detail in the Methods section below.

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<sup>31</sup> Friederici's model does not specify the type of morphosyntactic violations that should elicit a LAN. Therefore, we predict equal LANs for number agreement violations and gender agreement violations.

<sup>32</sup> All other factors (i.e., linear distance) being equal.

## **6. Methods**

### **6.1. Participants**

Eleven native speakers of Castilian Spanish (8 females and 3 males) participated in the experiment. Data from two participants (two males) were excluded from the analysis due to excessive artifacts in the recording. The age range of the remaining participants was 23 to 31, and their mean age was 27 years. All subjects were right-handed, as assessed by the Edinburgh Handedness Inventory, had normal or corrected to normal vision, and reported no history of neurological or linguistic disabilities.

Seven out of the nine subjects in the study reported being bilingual speakers of Castilian Spanish and another of Spain's official languages. More specifically, six participants reported being bilingual speakers of Castilian Spanish and Galician and one participant reported being a bilingual speaker of Castilian Spanish and Catalan. All of the bilingual participants reported having acquired both of their languages at birth, having been schooled in both languages, and feeling equally fluent in both of their languages.

Subjects were recruited through fliers and by word of mouth, and they received \$5 per half hour of participation in the study.

### **6.2. Stimuli**

#### **6.2.1. Experiment 1**

Experiment 1 consists of 120 triplets of 11-word sentences. Each triplet encompasses a grammatical sentence, a sentence with a number agreement violation, and a sentence with a gender agreement violation. A sample triplet is included in (60) below. The agreeing elements, a noun and an adjective, are underlined for ease of

reading. The agreement violations are indicated with an asterisk before the word where the mismatch became noticeable:

(60)

### Grammatical

- a. El banco es un edificio muy seguro  
the bank is a building-MASC-SG very safe-MASC-SG  
y el juzgado también.  
and the courthouse also.

“The bank is a very safe building and so is the courthouse.”

### Number Violation

- b. El banco es un edificio muy \*seguros  
the bank is a building-MASC-SG very safe-MASC-PL  
y el juzgado también.  
and the courthouse also.

Intended meaning: “The bank is a very safe building and so is the courthouse.”

### Gender Violation

- c. El banco es un edificio muy \*segura  
the bank is a building-MASC-SG very safe-FEM-SG  
y el juzgado también.  
and the courthouse also.

Intended meaning: “The bank is a very safe building and so is the courthouse.”

Agreement in Experiment 1 was computed **within the phrase** (a Determiner Phrase), that is, there was no syntactic distance between the agreeing elements. However, in terms of linear distance (the number of elements between the words in an agreement relationship), the agreeing elements were separated by one word, the adverb *muy* “very”. Crucially, for the two ungrammatical conditions, the violations became

noticeable on an adjective, where the gender and number features are uninterpretable and, therefore, syntactic rather than lexical.

A complete list of the 120 triplets used in Experiment 1 is provided in Appendix 1 (pages 117-126).

### **6.2.1.1. Predictions for Experiment 1**

As far as the effects of grammaticality are concerned, agreement violations (of both agreement categories) should yield a LAN and a P600, relative to their grammatical counterpart. Second, when it comes to comparing the processing of number and gender agreement, the late phase of the P600 should display greater amplitude for gender agreement violations than for number agreement violations.

### **6.2.1.2. Properties of the Stimuli in Experiment 1**

#### **6.2.1.2.1. Nouns in the DP of Interest**

Each of the 60 nouns within the DP of interest—the one that is predicate to the subject DP; i.e., *un edificio muy seguro* in (60a)—was used twice.<sup>33</sup> Half of the nouns in the DP of interest were masculine (a total of 30) and the other half, feminine. Whenever the noun in the DP of interest was masculine, all of the other nouns across the sentence, too, were masculine. The same consistency was observed for feminine nouns. The reason for keeping gender consistent across the sentence was to avoid potential attraction errors when computing agreement, a phenomenon that has been reported for both gender and, mainly, number agreement in Spanish (i.e., Antón-Méndez, Nicol, and Garrett, 2002).

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<sup>33</sup> It was decided to repeat the nouns in the DP of interest because the sentence requires a generic noun in that position (i.e., *sitio* “place”, *prenda* “garment”) and it would have been too difficult to retrieve 120 generic nouns that could be matched in frequency with the non-generic nouns in Experiment 2.

All nouns in the DP of interest exhibited canonical gender morphology, that is, all masculine nouns ended with the marker *-o*, which is strongly associated with the Spanish masculine gender, and all feminine nouns ended with the marker *-a*, which is strongly associated with the Spanish feminine gender (Harris, 1991).<sup>34</sup> In addition, all of the nouns referred to inanimate entities. Thus, no biological gender clues, which are considered to be semantic (and interpretable) rather than syntactic, were provided.

#### **6.2.1.2.2. Nouns outside of the DP of Interest**

One hundred and twenty more nouns were used to design the subject DPs in the sentences—i.e., *el banco* in (60) above. Finally, another set of 120 different nouns was used in the design of the coordinated DPs at the end of the sentences—i.e., *el juzgado* in (60) above. The reason for adding these coordinated DPs was to avoid having the agreement violations in sentence final position. This is because a number of studies (i.e., Hagoort & Brown, 1999; Hagoort, 2003) have reported sentence wrap-up effects (i.e., an N400) for words located at the end of a sentence, even when the sentence is grammatical.

Nouns outside the DP of interest were never repeated within Experiment 1 or across the whole study. As was the case with the nouns inside the DP of interest, they exhibited canonical gender morphology and provided no biological gender clues.

#### **6.2.1.2.3. Adjectives in the Critical Region**

A total of 79 adjectives were used in the critical region of Experiment 1—the adjective in the DP of interest; i.e., *un edificio muy seguro* in (60a).<sup>35</sup> As was the case

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<sup>34</sup> Although we acknowledge that *-o* and *-a* should be considered word markers, as opposed to gender morphemes, we will refer to these markers as “canonical gender morphology”.

<sup>35</sup> Out of those 79 adjectives, 41 occurred twice in Experiment 1 and the remaining 38 appeared once in Experiment 1 and once in Experiment 2. Initially, attempts were made to repeat adjectives within

with nouns, all adjectives across Experiment 1 exhibited canonical gender morphology, that is, they could be inflected both with the marker *-o* when agreeing with a masculine noun, and with the marker *-a* when agreeing with a feminine noun.

### 6.2.2. Experiment 2

Experiment 2 consisted of 120 triplets of 8-word sentences. Each triplet included a grammatical sentence, a sentence with a number agreement mismatch, and a sentence with a gender agreement violation. A sample triplet can be seen in (61) below. The agreeing elements, a noun and an adjective, are underlined for clarity. The agreement violations are indicated with an asterisk preceding the word where the mismatch became noticeable:

(61)

#### Grammatical

- a. El colegio es gratuito y el instituto también.  
the college-MASC-SG is free-MASC-SG and the high-school also  
“The college is free and so is the high school.”

#### Number Violation

- b. El colegio es \*gratuitos y el instituto también.  
the college-MASC-SG is free-MASC-PL and the high-school also  
Intended meaning: “The college is free and so is the high school.”

#### Gender Violation

- c. El colegio es \*gratuita y el instituto también.  
the college-MASC-SG is free-FEM-SG and the high-school also  
Intended meaning: “The college is free and so is the high school.”

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experiments, but it soon became apparent that it would not be possible to do so without compromising the semantic fit between a noun and its modifying adjective. Therefore, it was decided to privilege semantic appropriateness, to prevent lexical factors from interfering with the processing of agreement, the focus of the present study.



In Experiment 2, agreement was established across phrases, between the noun in the subject DP—i.e., *colegio* in (61a) above—and the adjective in the VP—i.e., *gratuito* in (61a). As far as linear distance is concerned, the agreeing words were separated by one word, the copula “be” inflected for third person singular present tense, *es*. As was the case in Experiment 1, the violations in the two ungrammatical conditions of the triplet were noticeable on adjectives, where the gender and number features are uninterpretable.

A complete list of the 120 triplets used in Experiment 2 is provided in Appendix 2 (pages 127-136).

To sum up, Experiments 1 and 2 were controlled for linear distance (there was one word between the agreeing elements in both experiments), but differed in terms of syntactic distance (the agreeing elements were in a local relationship in Experiment 1, but located across phrases in Experiment 2).

#### **6.2.2.1. Predictions for Experiment 2 and for the Distance Manipulation**

As in Experiment 1, both types of agreement violation should yield a LAN and a P600, relative to their grammatical counterpart. Second, the late phase of the P600 should display greater amplitude for gender agreement violations than for number agreement violations. Finally, as far as syntactic distance is concerned, agreement violations collapsed over agreement type should result in a greater late P600 in Experiment 2, where the agreeing elements are located across a phrase boundary, than in Experiment 1, where agreement is computed locally.

## **6.2.2.2. Properties of the Stimuli in Experiment 2**

### **6.2.2.2.1. Nouns in the DP of Interest**

Each of the 60 nouns within the DP of interest was used twice.<sup>36</sup> Half of the nouns in the DP of interest were masculine (a total of 30) and the other half, feminine. Gender was kept consistent across sentences, in order to avoid attraction errors. Finally, all nouns in the DP of interest exhibited canonical gender morphology and they all referred to inanimate entities, so that no biological gender clues were provided.

### **6.2.2.2.2. Nouns outside of the DP of Interest**

One hundred and twenty different nouns were used in the coordinated DPs at the end of the sentences—i.e., *el instituto* in (61) above. These nouns were never repeated within Experiment 2 or across the whole study. As was the case with the nouns inside the DP of interest, they exhibited canonical gender morphology and provided no biological gender clues.

### **6.2.2.2.3. Adjectives in the Critical Region**

A total of 79 adjectives were used in the critical region of Experiment 2—the adjective across the VP; i.e., *gratuito* in (61a).<sup>37</sup> All adjectives exhibited canonical gender morphology, that is, they could be inflected both with *-o* when agreeing with a masculine noun, and with *-a* when agreeing with a feminine noun.

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<sup>36</sup> Given that the nouns in the DP of interest of Experiment 1 had been repeated, it was decided to also repeat the nouns in Experiment 2 for consistency.

<sup>37</sup> Out of those 79 adjectives, 41 occurred twice in Experiment 2 and the remaining 38 appeared once in Experiment 2 and once in Experiment 1.

### 6.2.3. Experiment 3

Experiment 3 consisted of 120 triplets of 7-word sentences. Each triplet encompassed a grammatical sentence, a sentence with a number agreement violation, and a sentence with a gender agreement violation. A sample triplet is included in (62) below. The agreeing elements, a demonstrative and a noun, are underlined for ease of reading. The agreement violations are indicated with an asterisk before the word where the mismatch became noticeable:

(62)

#### Grammatical

- a. Mateo limpió este apartamento el sábado  
mateo cleaned this-MASC-SG apartment-MASC-SG the saturday  
pasado.  
last

“Mateo cleaned this apartment last Saturday.”

#### Number Violation

- b. Mateo limpió estos \*apartamento el sábado  
mateo cleaned these-MASC-PL apartment-MASC-SG the saturday  
pasado.  
last

Intended Meaning: “Mateo cleaned this apartment last Saturday.”

#### Gender Violation

- c. Mateo limpió esta \*apartamento el sábado  
mateo cleaned this-FEM-SG apartment-MASC-SG the saturday  
pasado.  
last

Intended Meaning: “Mateo cleaned this apartment last Saturday.”

Agreement in Experiment 3 was computed locally, **within the phrase** (a Determiner Phrase) that is, there was no syntactic distance between the agreeing elements. In terms

of linear distance, the agreeing elements were adjacent (no linear distance). For the two ungrammatical conditions, the violation was noticeable on a noun, where the gender and number features are interpretable.

A complete list of the 120 triplets used in Experiment 3 is provided in Appendix 3 (pages 137-146).

Experiments 1, 2, and 3 manipulate the syntactic category of the critical word (adjective vs. noun), which will allow us to investigate differences in the processing of agreement violations when the features are uninterpretable (Experiments 1 and 2: adjective) vs. interpretable (Experiment 3: noun).

#### **6.2.3.1. Predictions for Experiment 3**

As in Experiments 1 and 2, violations of both agreement types should yield a LAN and a P600, relative to their grammatical counterpart. Moreover, the late phase of the P600 should display greater amplitude for gender than for number mismatches.

#### **6.2.3.2. Properties of the Stimuli in Experiment 3**

##### **6.2.3.2.1. Nouns in the Critical Region**

Each of the 60 nouns in the critical region—the noun in the object DP; i.e., *este apartamento* in (62a) above—was used twice.<sup>38</sup> Half of the nouns in the critical region were masculine (a total of 30) and the other half, feminine. Gender was kept consistent across the sentence, to avoid attraction errors. All nouns in the critical region exhibited canonical gender morphology and they all referred to inanimate entities. Thus, no biological gender clues were provided.

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<sup>38</sup> It was decided to repeat the nouns in the critical region for consistency, as the adjectives in the critical regions of Experiments 1 and 2 were also repeated.

#### **6.2.3.2.2. Nouns outside the Critical Region**

Another set of 120 proper nouns was used for the subject DPs in the sentence—i.e., *Mateo* in (62) above. These nouns exhibited canonical gender morphology and, being proper nouns, provided a biological gender clue. Crucially, they were not in an agreement relationship with any other words in the sentence.

#### **6.2.3.2.3. Verbs**

Each of the 60 verbs in Experiment 3 was used twice. All verbs belonged to the first conjugation of the Spanish verb system, and they were all regular. Verbs appeared inflected for the third person singular *preterite*, i.e., *limpió* in (62).

#### **6.2.4. Fillers**

One hundred and twenty more sentences were added to the study as fillers. Given that across Experiments 1, 2, and 3 the ratio of grammatical to ungrammatical sentences was 1 to 2, it was decided to make all fillers grammatical in order to counterbalance the number of ungrammatical sentences in the study. This decision is motivated on two grounds. First, too many ungrammatical sentences could create a *no* response bias in the behavioral task (a Grammaticality Judgment Task). Second, the previous ERP literature has provided evidence that an excessive number of ungrammatical sentences can affect the processing of controlled processes like the ones indexed by the P600 (Hahne & Friederici, 1999), one of the components of interest in the present study.

Fillers were matched in length with the material from Experiment 1 (11-word sentences), Experiment 2 (8-word sentences), and Experiment 3 (7-word sentences). This resulted in forty 11-word fillers, forty 8-word fillers, and forty 7-word fillers. A sample of the three types of fillers is provided in (63) below:

(63)

### 11-Word Filler

- d. Lidia habló con una señora muy educada durante  
lidia talked with a lady-FEM-SG very polite-FEM-SG during  
toda la mañana.  
all the morning

“Lydia talked to a very polite lady for the whole morning.”

### 8-Word Filler

- e. Celia llamó a esta secretaria y Luisa  
celia called to this-FEM-SG secretary-FEM-SG and luisa  
también.  
also

“Celia called this secretary and so did Luisa.”

### 7-Word Filler

- f. Violeta entrevistó a una escritora muy distinguida.  
violeta interviewed to a writer-FEM-SG very distinguished-FEM-SG

“Violeta interviewed a very distinguished writer.”

Half of each 40-filler set was masculine (a total of 60 fillers) and the other half was feminine. As was the case with the experimental stimuli, gender was kept consistent within sentences, to facilitate their processing. All of the nouns and adjectives in the fillers exhibited canonical gender morphology, at least, in the form that was presented.<sup>39</sup> Contrary to the experimental stimuli, all of the nouns in the fillers provided a biological gender clue, which was expected to facilitate their processing by adding a semantic

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<sup>39</sup> Some of the nouns and adjectives in the fillers exhibited canonical gender morphology when inflected for one of the genders (i.e., *profesora* “female teacher”, *trabajadora*, “hard-working”) but not for the other (i.e., *profesor* “male teacher”, *trabajador*). In those cases, only the forms that exhibited canonical gender morphology were used.

clue. Finally, all of the verbs in the fillers were inflected for third person singular *preterite*.

For consistency purposes, all of the nouns, adjectives, and verbs in the fillers were repeated across fillers (a total of 60 nouns, 60 adjectives, and 60 verbs).

A complete list of the fillers used in the present study is provided in Appendix 4 (page 147-151).

### **6.2.5. Distribution of the Experimental Stimuli per Experimental Session**

The experiment was conducted in two sessions separated by a minimum of 2 days and a maximum of 7 days. Half of the triplets that were designed for each experiment and half of the fillers (20 of each filler type) were assigned to the first experimental session, a total of 180 triplets and 60 fillers. The remaining 180 triplets and 60 fillers were assigned to the second experimental session. The triplets were assigned to sessions in such a way that participants would only see one instance of the critical words. For example, in session 1, participants saw 60 different adjectives from Experiment 1, another 60 different adjectives from Experiment 2, and 60 different nouns from Experiment 3.

#### **6.2.5.1. Latin Square Lists**

Six Latin Square lists (three per experimental session) were designed so that each participant would only see one of the sentences in a given triplet. All participants saw all fillers. Participants were randomly assigned to one of the three Latin Square lists at each experimental session.

### **6.2.6. Frequency and Length Controls**

The controls below were performed in order to guarantee that lexical factors like frequency or length were not responsible for differences between experimental results. The LEXESP database was used to control the nouns and adjectives in the regions of interest for frequency. The checks were performed using the BuscaPalabras program (Davis & Perea, 2005).

### **6.2.7. Controls across Experiments**

#### **6.2.7.1. Experiment 1 vs. Experiment 2**

The adjectives in Experiments 1 and 2 were matched for frequency ( $p > 0.46$  two-tailed paired t-test) and length ( $p > 0.8$ ). The nouns in the DPs of interest of Experiments 1 and 2 were also matched for frequency ( $p > 0.45$ ) and length ( $p > 0.45$ ).

#### **6.2.7.2. Experiment 1 vs. Experiment 3**

The nouns in Experiments 1 and 3 were controlled for frequency ( $p > 0.37$ ) and length ( $p > 0.75$ ).

#### **6.2.7.3. Experiment 2 vs. Experiment 3**

The nouns in Experiments 2 and 3 were controlled for frequency ( $p > 0.97$ ) and length ( $p > 0.8$ ).

### **6.2.8. Controls within Experimental Sessions**

As mentioned in section 6.2.5, the 120 triplets in each experiment were assigned to two different experimental sessions. Therefore, frequency and length checks were run to confirm that experiments were controlled within each experimental session.



#### **6.2.8.1. Experimental Session 1: Experiment 1 vs. Experiment 2**

The adjectives in Experiments 1 and 2 were matched for frequency ( $p > 0.38$ ) and length ( $p > 0.79$ ). The nouns in the DPs of interest of Experiments 1 and 2 were also matched for frequency ( $p > 0.69$ ) and length ( $p > 0.97$ ).

#### **6.2.8.2. Experimental Session 1: Experiment 1 vs. Experiment 3**

The nouns in Experiments 1 and 3 were matched for frequency ( $p > 0.7$ ) and length ( $p > 0.75$ ).

#### **6.2.8.3. Experimental Session 1: Experiment 2 vs. Experiment 3**

The nouns in Experiments 2 and 3 were controlled for frequency ( $p > 0.97$ ) and length ( $p > 0.72$ ).

#### **6.2.8.4. Experimental Session 2: Experiment 1 vs. Experiment 2**

The adjectives in Experiments 1 and 2 were matched for frequency ( $p > 0.99$ ) and length ( $p > 0.77$ ). The nouns in the DPs of interest of Experiments 1 and 2 were also matched for frequency ( $p > 0.48$ ) and length ( $p > 0.48$ ).

#### **6.2.8.5. Experimental Session 2: Experiment 1 vs. Experiment 3**

The nouns in Experiments 1 and 3 were controlled for frequency ( $p > 0.57$ ) and length ( $p > 0.4$ ).

#### **6.2.8.6. Experimental Session 2: Experiment 2 vs. Experiment 3**

The nouns in Experiments 2 and 3 were controlled for frequency ( $p > 0.80$ ) and length ( $p = 1$ ).

### **6.2.9. Controls across Experimental Sessions**

Checks were run to confirm that, for a given experiment, the critical words were balanced across sessions, to prevent one experimental session from containing, for example, all of the most infrequent or longest nouns and adjectives.

#### **6.2.9.1. Experiment 1: Session 1 vs. Session 2**

Across the two experimental sessions, the adjectives in Experiment 1 were matched for frequency ( $p > 0.77$ ) and length ( $p = 1$ ). The nouns in the DPs of interest of Experiments 1 were also matched for frequency ( $p > 0.88$ ) and length ( $p > 0.3$ ).

#### **6.2.9.2. Experiment 2: Session 1 vs. Session 2**

Across the two experimental sessions, the adjectives in Experiment 2 were matched for frequency ( $p > 0.62$ ) and length ( $p = 1$ ). The nouns in the DPs of interest of Experiments 2 were also matched for frequency ( $p > 0.87$ ) and length ( $p > 0.75$ ).

#### **6.2.9.3. Experiment 3: Session 1 vs. Session 2**

Across the two experimental sessions, the nouns in the DP of interest in Experiments 3 were matched for frequency ( $p = 1$ ) and length ( $p = 1$ ).

### **6.3. Procedure**

Participation in the study involved two visits to the University of Kansas Neurolinguistics and Language Processing Lab. As mentioned earlier, the two visits were separated by a minimum of 2 days and a maximum of 7 days. This time interval between both experimental sessions was expected to neutralize the priming effects that might have arisen from the repetition of the critical words in the study. Each visit to the

lab lasted for approximately 3 hours. During the first visit, participants gave written consent to participate in the study, filled out a background questionnaire, completed the Edinburgh Handedness Inventory, and carried out the first EEG session. During the second visit, subjects completed the second EEG session and a Gender Assignment Task.

### **6.3.1. EEG Sessions**

Participants were randomly assigned to one of the three Latin Square lists at each experimental session. After being fitted with the electrode cap, subjects were seated in a dimly lit room in front of a computer monitor. Participants received both spoken and written instructions to silently read sentences and evaluate whether they were grammatical sentences of Spanish. They did so by pressing a joystick button with their left hand at the end of every sentence. It was decided to have participants perform the Grammaticality Judgment Task with their left hand because the left hand is controlled by the right hemisphere, which is assumed to be the least dominant hemisphere for language. The Grammaticality Judgment Task was chosen following Barber & Carreiras (2005). Subjects were instructed not to blink during the presentation of the sentences. They were encouraged to blink upon presentation of the prompts for the Grammaticality Judgment (*Bien* “good” and *Mal* “bad”) at the end of each sentence. They were also told not to press the joystick button until they saw the prompts at the end of each trial.

Each session began with a practice set consisting of nine sentences, none of which included a number/gender agreement violation. In order to avoid priming or repetition effects, none of the words used in the practice sentences appeared in the experimental sentences. Participants received written feedback for the first three trials. The presentation of the remaining six was identical to that of the experimental stimuli. After

completing the practice session, the experiment began. Each session consisted of six blocks of 40 sentences separated by five short breaks. Presentation of the experimental sentences was randomized.

### **6.3.2. Trial Structure**

Sentences were visually presented one word at a time using the RSVP (Rapid Serial Visual Presentation) method. Each sentence began with a fixation cross that remained on the center of the screen for 500ms. Immediately after the fixation cross, the presentation of the experimental material began. Each word was presented for 450ms, followed by a 300ms pause. At the end of each sentence, there was a 1000ms pause followed by the prompts for the Grammaticality Judgment, the word *Bien* for correct trials (on the right of the screen) and the word *Mal* for ungrammatical trials (on the left). Responses to correct and incorrect trials were made with the index and middle fingers, respectively. The prompts remained on the screen until the participant pressed one of the two buttons of the joystick. Following the behavioral response, there was an interval between trials ranging from 500-1000ms, pseudorandomly varied at 50ms increments. Immediately after this interval, the next trial began.

Sentences were presented in black text (Courier New font) on a dark grey background. All Spanish words exhibited the appropriate diacritics and the last word of each sentence was followed by a period. The presentation of the stimuli was carried out using the Paradigm program by Perception Research Systems Inc. (Tagliaferri, 2005).

### **6.4. Gender Assignment Task: Procedure**

After completing the second EEG session, participants completed a Gender Assignment Task, the purpose of which was to determine whether subjects could access

the grammatical gender of the nouns in the critical regions of Experiments 1-3. Ultimately, the purpose of the Gender Assignment Task was to make sure that any errors on the Grammaticality Judgment Task were not due to problems with gender assignment. Subjects were seated in front of a computer monitor in a quiet room and given both spoken and written instructions to silently read a series of 180 nouns and chose the definite determiner with which they agreed (two options: feminine singular *La* or masculine singular *El*).

The task began with a practice set consisting of 5 trials. Participants did not receive any feedback during the practice to avoid providing too much explicit information about the nature of the task. Likewise, none of the nouns used in the practice had been used in any of the three experiments. After completing the practice session, the task began. Each session consisted of three blocks of 60 words separated by two short breaks. Presentation of the experimental sentences was randomized.

#### **6.4.1. Gender Assignment Task: Trial Structure**

Each trial began with a fixation cross that remained on the center of the screen for 500ms. Immediately after the fixation cross, the noun was presented for 450ms, in order to emulate the circumstances under which subjects retrieved the gender of a given noun in Experiments 1-3. Following the presentation of each noun, there was a 1000ms pause followed by a screen with the feminine determiner *La* (on the right of the screen) and the masculine determiner *El* (on the left). Subjects chose the correct determiner by placing the pointer of a computer mouse on it and clicking on the left button. The determiners remained on the screen until the participant selected one of them with the left button of the mouse. Words were presented in black text (Courier New font) on a dark grey background and they all exhibited the appropriate diacritics. The presentation

of the stimuli was carried out using the Paradigm program by Perception Research Systems Inc. (Tagliaferri, 2005).

### **6.5. EEG Recording**

The EEG was continuously recorded using an elastic electrode cap (Electro-Cap International, Inc.) containing 29 sintered Ag/AgCl scalp electrodes arrayed in a modified 10-20 layout (midline: FPZ, FZ, FCZ, CZ, CPZ, PZ, OZ; lateral: F7/8, F3/4, FT7/8, FC3/4, T3/4, C3/4, TP7/6, CP3/4, T5/6, P3/4, O1/2). Eye blinks and eye movements were monitored with an additional six electrodes placed on the left and right outer canthi, and above and below each eye. Reference electrodes were placed on the left and right mastoids. The linked mastoid electrodes served as a reference and electrode AFZ served as ground. Impedances for each electrode were kept below 5 k $\Omega$ . The recordings were amplified by a Neuroscan Synamps2 amplifier (Compumedics Neuroscan, Inc.) with a bandpass of 0.01 to 100 Hz and digitized at a sampling rate of 1 kHz.

### **6.6. EEG Data Analysis**

The EEG data analysis was carried out using the Neuroscan SCAN software (Compumedics Neuroscan, Inc.). The analysis involved all experimental trials regardless of accuracy in the Grammaticality Judgment Task (at ceiling). Trials including eye blinks, eye movements, excessive muscle activity, or excessive alpha waves were excluded from further analysis. The continuous EEG was then segmented into epochs relative to the critical word (for all three conditions in the three experiments). Epochs started 300ms before the critical word—the length of the pause preceding the critical word—and ended 1200ms after it. After the artifact rejection and

epoching processes, trials were averaged together per experimental condition and corrected relative to a 300ms pre-stimulus baseline. Finally, averaged trials were filtered with a 30Hz low-pass filter.

The grand-averaged waveforms for each of the nine conditions were generated in order to determine the time-windows of interest for calculating ERPs. Upon visual observation of the grand-averaged waveforms, ERPs were quantified through the mean amplitudes of three time windows: (1) the 150-400ms window, (2) the 250-400ms window, which include the canonical LAN, and (3) the 400-900ms time window, which includes the canonical P600. Given that the previous literature has posited that the P600 comprises an early and a late phase (Hagoort, Brown, & Osterhout, 1999; Hagoort & Brown, 2000; Barber & Carreiras, 2005), additional ERPs were quantified via the mean amplitudes for the 400-650ms and 650-900ms windows.

## **7. Results**

### **7.1. Behavioral Results**

Participants performed at ceiling in all nine conditions of the Grammaticality Judgment Task, suggesting that they could easily detect number and gender agreement violations in all three experiments. As expected, subjects also performed at ceiling in the Gender Assignment Task, which indicates that they knew the grammatical gender of the nouns in the critical regions and could access it under similar processing constraints to those in the Grammaticality Judgment Task. Table 1 below includes the mean accuracy rates for all nine conditions of the Grammaticality Judgment Task and for the Gender Assignment Task (data from 9 participants):

**Table 1:** Mean accuracy rates in the Grammaticality Judgment Task (all nine conditions) and in the Gender Assignment Task (figures are rounded to the closest decimal place).

Experiment	Condition	Accuracy Rate
Grammaticality Judgment Task Experiment 1	Grammatical	98.1 %
	Number Violation	99.5 %
	Gender Violation	99.8 %
Grammaticality Judgment Task Experiment 2	Grammatical	98.1 %
	Number Violation	98.7 %
	Gender Violation	99.2 %
Grammaticality Judgment Task Experiment 3	Grammatical	98.9 %
	Number Violation	97.5 %
	Gender Violation	98.7 %
Gender Assignment Task		99.9 %

## 7.2. Neurophysiological Results

### 7.2.1. Analyses on Single Electrodes

A series of t-tests were conducted on all 32 electrodes to test for the effects of grammaticality on the amplitude of the LAN and the P600 in all three experiments. The tests for the LAN were performed on two different time windows: 150-400ms and 250-400ms. The tests for the P600 were conducted on the 400-900ms time window. Based on previous descriptions of the P600 (Hagoort & Brown, 2000; Barber & Carreiras, 2005), additional tests were performed on the early and late phases of this component: 400-650ms and 650-900ms.

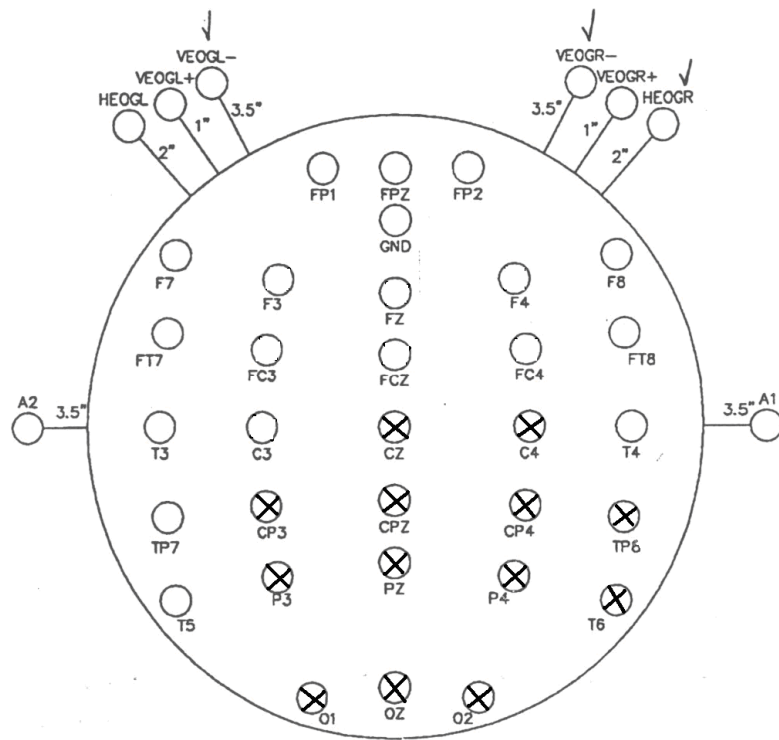
The results of the t-tests revealed no systematic effects of grammaticality on the LAN in either of the two time windows under investigation (150-400ms, 250-400ms). In other words, none of the 32 electrodes showed a consistent LAN effect for both number and gender agreement violations in all three experiments. By contrast, a consistent effect of grammaticality was found for a number of electrodes in the three time windows associated with the P600 (400-900ms, 400-650ms, and 650-900ms). In other words, a series of electrodes in each time window showed a P600 effect for both number and gender agreement violations in all three experiments.



Based on the results of the t-tests, a repeated measures Analysis of Variance (hereinafter ANOVA) was conducted for every electrode that showed a significant effect of grammaticality for both number and gender agreement violations in all three experiments. The LAN was, therefore, excluded from further analysis.

### 7.2.1.1. P600 (400-900ms) : Experiments 1, 2, and 3

A one-way repeated measures ANOVA was conducted for each of the following electrodes: CPZ, CP3, P4, O1, PZ, C4, T6, O2, CP4, P3, OZ, CZ, and TP6. As can be seen in Figure 1 below, all of these electrodes show a central or posterior distribution, corresponding to the canonical topography of the P600.



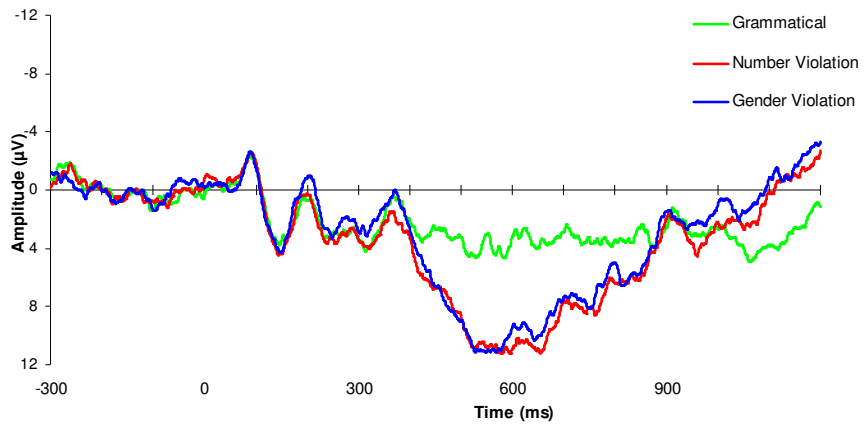
**Figure 1:** Electro-cap layout indicating the electrodes which showed a significant effect of grammaticality (marked with a cross) in the 400-900ms time window.

The general trend revealed by the statistical analysis on single electrodes is that, for all of the above central-posterior electrodes, number agreement violations and gender agreement violations resulted in a more positive wave than their grammatical counterpart between 400 and 900ms, an effect that was statistically significant in all three experiments. In addition, the statistical analyses showed that number agreement violations and gender agreement violations did not significantly differ in any of the electrodes. Figures 2, 3, and 4 (page 83) show the grand average mean amplitudes for grammatical sentences, number agreement violations, and gender agreement violations in Experiments 1, 2, and 3, respectively. Results are plotted for posterior electrode PZ. Table 2 (page 84) summarizes the effects of grammaticality on the electrodes under investigation (for all three experiments). The  $F$  values for the comparison between number agreement violations and gender agreement violations are also included. For a more detailed account of the analysis on single electrodes in Experiments 1, 2, and 3 (including  $F$  values for each relevant comparison), see Appendixes 5, 6, and 7.<sup>40</sup>

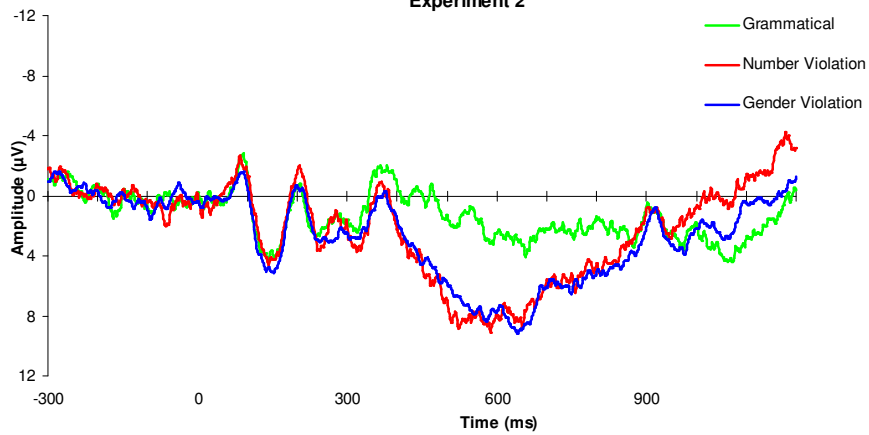
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<sup>40</sup> Pages 152, 156, and 160 respectively.

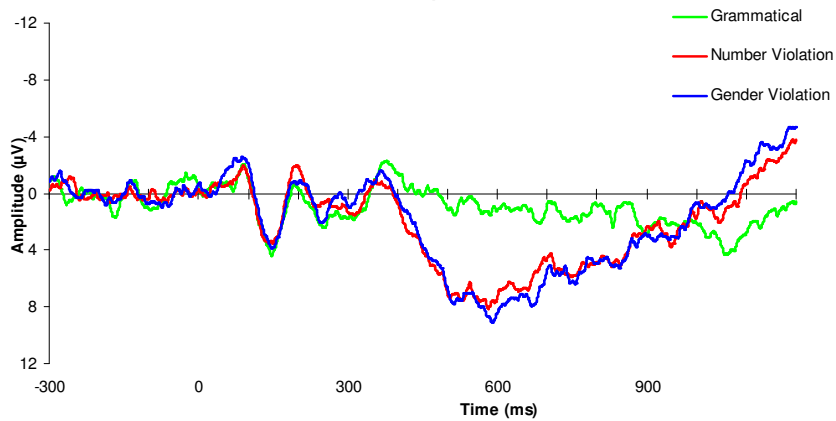
**Figure 2: ERP Responses to Grammatical Sentences, Number Agreement Violations, and Gender Agreement Violations  
Experiment 1**



**Figure 3: ERP Responses to Grammatical Sentences, Number Agreement Violations, and Gender Agreement Violations  
Experiment 2**



**Figure 4: ERP Responses to Grammatical Sentences, Number Agreement Violations, and Gender Agreement Violations  
Experiment 3**



**Table 2:** *F* values and significance levels indicated by post-hoc tests comparing the mean amplitude of number and gender agreement violations respectively to the mean amplitude of their grammatical counterparts in the 400-900ms time-window in all three experiments

Electrode	Experiment 1			Experiment 2			Experiment 3		
	Grammatical vs. Number	Grammatical vs. Gender	Number vs. Gender	Grammatical vs. Number	Grammatical vs. Gender	Number vs. Gender	Grammatical vs. Number	Grammatical vs. Gender	Number vs. Gender
CPZ	**13.497	*8.301	.586	***15.815	***20.835	.032	***15.594	***25.10	.353
CP3	*7.853	*6.875	2.119	***22.886	***15.99	.001	***19.085	***24.087	.352
P4	***22.324	**13.113	.53	***20.639	***19.053	.067	***21.50	***38.431	.009
O1	***15.622	***14.772	.001	**11.858	***19.204	.012	***37.632	***31.501	1.428
PZ	***14.245	*8.854	.635	***21.377	***21.334	.000	***27.511	***33.323	.30
C4	*5.703	*7.03	.49	**12.3	*10.987	.000	*8.548	*8.843	2.252
T6	***38.301	***30.67	.31	***45.858	***24.836	.065	***27.313	***22.015	2.207
O2	***16.543	**12.903	.112	*10.461	**13.902	.191	***16.832	***19.582	2.111
CP4	***21.76	**11.167	.43	**20.378	***15.407	.067	***22.609	***32.013	1.137
P3	**11.864	*9.886	.524	***33.141	***21.288	.044	***29.164	***28.738	.000
OZ	**13.265	**12.429	.62	*10.357	***21.647	.62	***25.783	***24.211	1.595
CZ	**13.265	**12.429	.062	**11.813	***15.379	.128	*10.797	**14.019	1.359
TP6	***14.258	***15.019	.1	***40.132	**13.687	.737	***27.313	***22.015	2.207

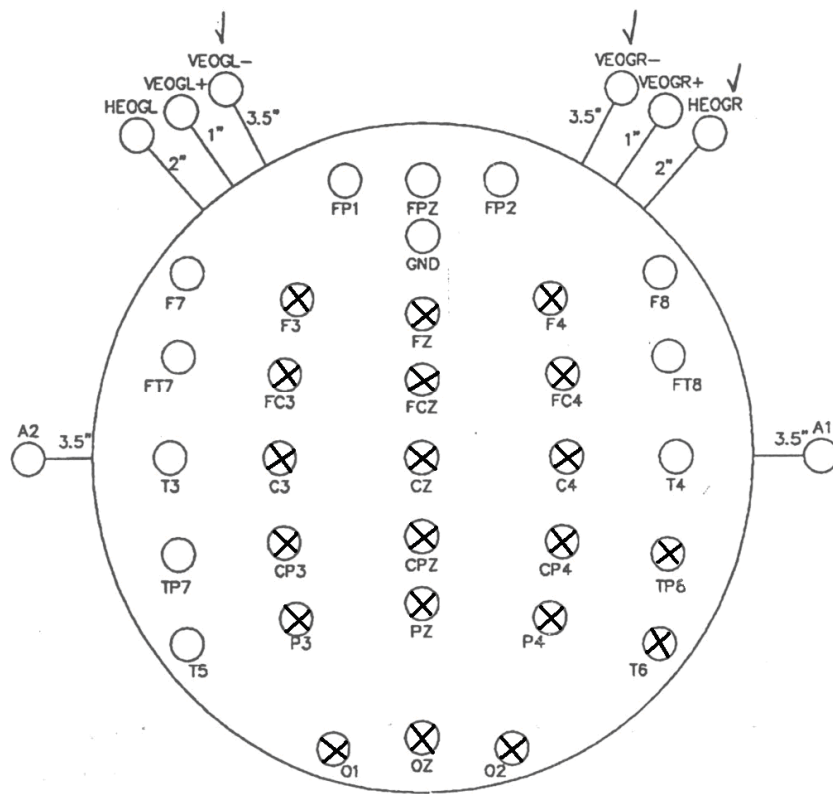
\*  $p > .05$

\*\*  $p > .01$

\*\*\*  $p > .005$

### 7.2.1.2. P600 (400-650 ms) : Experiments 1, 2, and 3

A one-way repeated measures ANOVA comparing each ungrammatical condition to its grammatical counterpart was conducted for each of the following electrodes: CPZ, FC4, CP3, P4, O1, FZ, PZ, C4, F4, T6, O2, FCZ, F3, C3, CP4, P3, OZ, CZ, FC3, and TP6. The t-tests for each of these electrodes had shown a significant effect of grammaticality between 400-650ms for both number agreement violations and gender agreement violations in all three experiments. As can be seen in Figure 5 below, the distribution of the effect is broader than in the 400-900ms time-window, as it now includes more electrodes from the frontal region:



**Figure 5:** Electro-cap layout indicating the electrodes which showed a significant effect of grammaticality (marked with a cross) in the 400-650ms time window.

Results indicated a similar trend to that observed in the 400-900ms time-window across experiments, that is, the grammatical condition was always significantly less

positive than both violation conditions, which, in turn, were never significantly different. Table 3 (page 87) provides the *F* values and significance levels revealed by post-hoc tests comparing the violation conditions to their grammatical counterparts. The *F* values for the comparison between number agreement violations and gender agreement violations are also included:

**Table 3:** *F* values and significance levels indicated by post-hoc tests comparing the mean amplitude of number and gender agreement violations respectively to the mean amplitude of their grammatical counterparts in the 400–650ms time-window in all three experiments

Electrode	Experiment 1			Experiment 2			Experiment 3		
	Grammatical vs. Number	Grammatical vs. Gender	Number vs. Gender	Grammatical vs. Number	Grammatical vs. Gender	Number vs. Gender	Grammatical vs. Number	Grammatical vs. Gender	Number vs. Gender
CPZ	***30.651	***34.739	.105	***15.678	***19.213	.024	***23.736	***16.599	.362
FC4	*8.474	***30.338	.034	**12.4	*9.14	.043	***14.851	*10.57	2.039
CP3	***24.075	***32.661	.880	***14.855	***13.694	.164	***26.732	***14.946	.066
P4	***49.632	***31.701	.132	***20.297	***16.406	.739	***49.523	***18.809	.249
O1	***21.371	***15.546	.016	*8.485	*10.951	.815	***15.031	***15.228	.425
FZ	**13.195	***40.733	.456	*9.697	**12.042	.409	**11.178	***17.176	.689
PZ	***37.497	***33.941	.244	***21.794	***20.466	.563	***31.689	***21.494	.059
C4	***18.689	***52.036	.067	**13.931	**11.307	.005	***14.582	*8.925	1.981
F4	**10.491	***19.531	.217	***15.828	*6.743	.016	**10.116	***12.903	1.121
T6	***36.249	***32.800	.685	***25.624	***17.311	.984	***26.644	**12.477	.710
O2	***24.184	***15.722	.087	*9.216	*10.375	1.869	*9.925	*10.067	.422
FCZ	***14.787	***43.615	.403	**11.921	**12.742	.205	***15.501	***18.177	.583
F3	*8.104	***19.754	.702	*5.805	*7.709	.563	*9.344	**12.005	.388
C3	***14.257	***31.590	.612	*10.891	**12.207	.001	***21.109	**13.524	1.434
CP4	***48.708	***43.896	.005	***20.385	**14.173	.33	***31.346	***15.396	1.09
P3	***27.994	***22.170	.161	***17.229	***15.496	.583	***34.199	***18.058	.006
OZ	***20.443	***15.343	.065	*8.491	**13.754	.444	**13.214	**12.273	.31
CZ	***24.386	***38.132	.308	**13.043	***15.471	.085	***20.922	***14.653	.834
FC3	*7.274	**13.537	.985	*8.438	*10.482	.221	*10.895	*8.771	1.117
TP6	***25.558	***94.656	1.429	***38.448	**13.756	1.652	***36.092	***22.334	.015

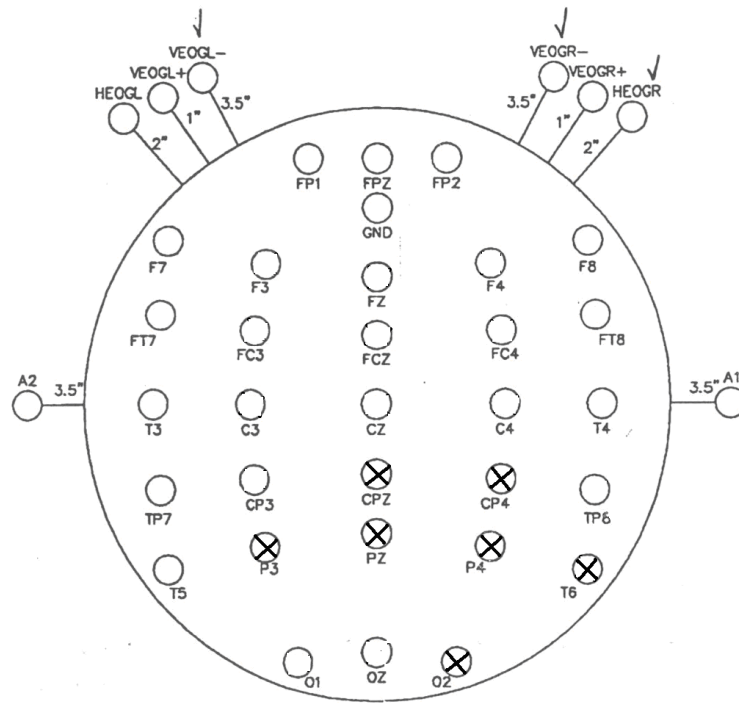
\*  $p > .05$

\*\*  $p > .01$

\*\*\*  $p > .005$

### 7.2.1.3. P600 (650-900 ms): Experiments 1, 2, and 3

A one-way repeated measures ANOVA comparing each ungrammatical condition to its grammatical counterpart was conducted for each of the following electrodes (in all three experiments): CPZ, P4, PZ, T6, O2, CP4, and P3. The t-tests for each of these electrodes had shown a significant effect of grammaticality between 650-900ms for both number agreement violations and gender agreement violations in all three experiments. As can be seen in Figure 6 below, the distribution of the effect is almost exclusively parietal (Barber & Carreiras, 2005; Hagoort, Brown, & Osterhout, 1999) and smaller than in the previous time-windows:



**Figure 6:** Electro-cap layout indicating the electrodes which showed a significant effect of grammaticality (marked with a cross) in the 650-900ms time window.

Results indicated a similar trend to that observed in the 400-900ms and 650-900ms time-windows in the three experiments, that is, the grammatical condition was always significantly less positive than both violation conditions, but the difference between



both violation conditions was never statistically significant. Table 4 (page 90) summarizes the *F* values and significance levels indicated by post-hoc tests comparing the violation conditions to their grammatical counterpart. The *F* values for the comparison between number agreement violations and gender agreement violations are also included:

**Table 4:** *F* values and significance levels indicated by post-hoc tests comparing the mean amplitude of number and gender agreement violations respectively to the mean amplitude of their grammatical counterparts in the 650-900ms time-window in all three experiments

Electrode	Grammatical		Grammatical		Grammatical		Grammatical		Grammatical		Grammatical		Grammatical	
	vs. Number	Gender	vs. Number	Gender	vs. Number	Gender	vs. Number	Gender	vs. Number	Gender	vs. Number	Gender	vs. Number	Gender
<b>CPZ</b>	***24.404	***34.195	***5.645	***19.077	***6.607	***17.034	***11.897	***19.056	***12.279	***29.608	***11.897	***25.581	***12.263	***24.652
<b>P4</b>	***33.039	***61.549	*7.518	***19.056	**12.279	***29.608	**11.897	***15.373	**12.279	***29.608	**11.897	***25.581	**12.263	***19.364
<b>PZ</b>	***21.741	***41.840	*6.075	***15.373	**11.897	***25.581	**11.897	***15.373	**11.897	***25.581	**11.897	***25.581	**11.897	***19.364
<b>T6</b>	***19.591	***27.490	***5.37	***30.810	**12.263	***30.810	**12.263	***30.810	**12.263	***30.810	**12.263	***30.810	**12.263	***19.364
<b>O2</b>	**12.535	***17.441	*6.575	**13.111	**13.772	***17.441	**13.111	**13.111	**13.772	***17.441	**13.111	***17.441	**13.772	***19.364
<b>CP4</b>	***18.726	***38.851	*6.764	***14.601	*8.081	***38.851	***14.601	***14.601	*8.081	***17.075	*8.081	***17.075	*8.081	***17.075
<b>P3</b>	***20.564	***23.540	*6.764	***23.746	*9.625	***23.540	***23.746	***23.746	*9.625	***17.843	*9.625	***17.843	*9.625	***17.843

\*  $p > .05$

\*\*  $p > .01$

\*\*\*  $p > .005$

### 7.2.2. Analyses on Regions of Interest

Based on Barber & Carreiras (2005), 20 out of the 32 electrodes in the EEG were assigned into four regions of interest (Left Anterior, Left Posterior, Right Anterior, and Right Posterior) in order to investigate a potential interaction between grammaticality and the topography of the effects. Region Left Anterior included electrodes FP1, F7, F3, FT7, and FC3. Region Left Posterior comprised electrodes TP7, CP3, T5, P3, and O1. Region Right Anterior consisted of electrodes FP2, F8, F4, FT8, and FC4. Finally, region Right Posterior contained electrodes TP6, CP4, T6, P4, and O2. The value of each region of interest was computed by averaging the mean amplitudes of all the electrodes in the region.

T-tests comparing each violation condition with its grammatical counterpart in the time-windows created for the LAN and the P600 were then conducted for the four regions of interest. The tests for the LAN were performed on two different time windows: 150-400ms and 250-400ms. The tests for the P600 were conducted on three different time windows: 400-900ms, 400-650ms, and 650-900ms.

The results of the t-tests revealed no systematic effects of grammaticality in any of the two time-windows selected for the LAN. In other words, none of the regions of interest showed a consistent LAN effect for both number and gender agreement violations in all three experiments. Crucially, this was true even for the Left Anterior region, which corresponds to the canonical topography of the Left Anterior Negativity. The LAN was, therefore, excluded from further analysis. Table 5 below (page 92) includes the *p* values revealed by the t-tests comparing each violation condition to its grammatical counterpart in the time windows associated with the LAN:

**Table 5:** *p* values indicated by t-tests comparing the mean amplitude of number and gender agreement violations respectively to the mean amplitude of their grammatical counterparts in the 150-400ms and 250-400ms time-windows in all three experiments.

Time window	Region	Number Exp. 1	Gender Exp. 1	Number Exp. 2	Gender Exp. 2	Number Exp. 3	Gender Exp. 3
150-400ms	Left Anterior	.76	<b>*.048</b>	.55	.10	.13	.95
	Left Posterior	.64	.09	.05	.87	<b>*.01</b>	.10
	Right Anterior	.38	.22	.40	.12	<b>*.03</b>	.22
	Right Posterior	.81	.48	.39	.22	.67	.62
250-400ms	Left Anterior	.74	.07	.31	.12	.15	.83
	Left Posterior	.62	.11	.40	.95	.08	<b>*.04</b>
	Right Anterior	.53	.45	.27	.11	<b>*.02</b>	.19
	Right Posterior	.69	.75	.11	.14	.74	.64

\*  $p > .05$

The table above shows that some LAN-effects did emerge in both the 150-400ms and the 250-400ms time windows, although not consistently across agreement type or experiment. Despite the lack of grammaticality effects for the LAN, a consistent effect of grammaticality was found in all of the time-windows created for the P600, with number and gender agreement violations being more positive than their grammatical counterparts in all three experiments. In the time-window selected for the whole P600 (400-900ms), the effect was significant in the two posterior regions, which is consistent with the canonical posterior distribution of the P600. In the early phase of the P600 (400-650ms), the effect was significant in the two posterior regions and the right anterior region. Finally, in the later phase of the P600 (650-900ms), the effect was only significant in the right posterior region. This distribution, which was expected, suggests that the first phase of the P600 made a greater contribution to the whole P600 than the second phase.

Based on the results of the t-tests, a series of two-way repeated measures ANOVAs was conducted in order to investigate a potential interaction between factors grammaticality and region (3 x 4) in the three time-windows of the P600 under investigation.

### **7.2.2.1. P600 (400-900ms)**

#### **7.2.2.1.1. Experiment 1**

A significant main effect of grammaticality was found in the omnibus ANOVA [ $F(2,16) = 7.631$ ;  $p < .005$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 9.728$ ;  $p < .014$ ] and gender agreement violations [ $F(1,8) = 7.855$ ;  $p < .023$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = 1.678$ ;  $p < .231$ ].

A significant main effect of region was found in the omnibus ANOVA [ $F(1.594, 12.756) = 32.714$ ;  $p < .001$ ] after applying the Greenhouse-Geisser test to correct for a potential violation of the sphericity assumption. Post-hoc tests indicated that Left Posterior was significantly more positive than Right Anterior [ $F(1,8) = 40.472$ ;  $p < .001$ ] and Left Anterior [ $F(1,8) = 44.111$ ;  $p < .001$ ], and that Right Posterior was significantly more positive than Right Anterior [ $F(1,8) = 39.300$ ;  $p < .001$ ] and Left Anterior [ $F(1,8) = 26.994$ ;  $p < .001$ ]. However, the difference between both posterior regions failed to reach statistical significance [ $F(1,8) = 3.932$ ;  $p < .083$ ].

A significant grammaticality by region interaction was found in the omnibus ANOVA [ $F(1.78, 14.238) = 5.216$ ;  $p < .023$ ] after applying the Greenhouse-Geisser test to correct for a potential violation of the sphericity assumption. The interaction was driven by the fact that both posterior regions became more positive when an agreement violation was detected, but both anterior regions remained relatively unaffected.

#### **7.2.2.1.2. Experiment 2**

A significant main effect of grammaticality was found in the omnibus ANOVA [ $F(2,16) = 8.808$ ;  $p < .003$ ]. Post-hoc tests indicated that grammatical sentences were

significantly less positive than number agreement violations [ $F(1,8) = 19.111$ ;  $p < .002$ ] and gender agreement violations [ $F(1,8) = 11.957$ ;  $p < .009$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .28$ ;  $p < .870$ ].

A significant main effect of region was found in the omnibus ANOVA [ $F(1.605, 12.836) = 7.545$ ;  $p < .009$ ] after applying the Greenhouse-Geisser test to correct for a potential violation of the sphericity assumption. Post-hoc tests indicated that Left Posterior was significantly more positive than Right Anterior [ $F(1,8) = 9.091$ ;  $p < .017$ ] and Left Anterior [ $F(1,8) = 11.327$ ;  $p < .010$ ], and that Right Posterior was significantly more positive than Right Anterior [ $F(1,8) = 7.766$ ;  $p < .024$ ] and Left Anterior [ $F(1,8) = 6.816$ ;  $p < .031$ ]. However, the difference between both posterior regions failed to reach statistical significance [ $F(1,8) = .811$ ;  $p < .394$ ].

A significant grammaticality by region interaction was found in the omnibus ANOVA [ $F(6, 48) = 6.54$ ;  $p < .001$ ]. The interaction was driven by the fact that both posterior regions and Right Anterior became more positive when an agreement violation was detected, but Left Anterior remained relatively unaffected

### **7.2.2.1.3. Experiment 3**

A significant main effect of grammaticality was found in the omnibus ANOVA [ $F(2,16) = 14.289$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 16.667$ ;  $p < .004$ ] and gender agreement violations [ $F(1,8) = 36.790$ ;  $p < .001$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .825$ ;  $p < .390$ ].

A significant main effect of region was found in the omnibus ANOVA [ $F(1.963, 24.327) = 5.332$ ;  $p < .017$ ] after applying the Greenhouse-Geisser test to correct for a potential violation of the sphericity assumption. Post-hoc tests indicated that Left Posterior was significantly more positive than Right Anterior [ $F(1,8) = 9.951$ ;  $p < .014$ ] and Left Anterior [ $F(1,8) = 8.313$ ;  $p < .020$ ], and that Right Posterior was significantly more positive than Right Anterior [ $F(1,8) = 5.317$ ;  $p < .05$ ]. However, contrary to the pattern found in Experiments 1 and 2, Right Posterior was not significantly different from Left Anterior [ $F(1,8) = 2.112$ ;  $p < .184$ ]. In addition, the difference between both posterior regions did reach statistical significance [ $F(1,8) = 6.761$ ;  $p < .032$ ].

A significant grammaticality by region interaction was found in the omnibus ANOVA [ $F(3.016, 24.131) = 4.111$ ;  $p < .017$ ] after applying the Greenhouse-Geisser test to correct for a potential violation of the sphericity assumption. The interaction was driven by the fact that both posterior regions became more positive when an agreement violation was detected, but both anterior regions remained relatively unaffected by gender—but not number—agreement violations.

#### **7.2.2.2. P600 (400-650ms)**

Based on the results of the t-tests, a series of two-way repeated measures ANOVAs was conducted in order to investigate a potential interaction between factors grammaticality and region (3 x 4) in the 400-650ms time-window.

##### **7.2.2.2.1. Experiment 1**

A significant main effect of grammaticality was found in the omnibus ANOVA [ $F(2,16) = 27.471$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 32.857$ ;  $p < .001$ ]

and gender agreement violations [ $F(1,8) = 54.808$ ;  $p < .001$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .120$ ;  $p < .738$ ].

A significant main effect of region was found in the omnibus ANOVA [ $F(1.787, 14.294) = 19.388$ ;  $p < .001$ ] after applying the Greenhouse-Geisser test to correct for a potential violation of the sphericity assumption. Post-hoc tests indicated that Left Posterior was significantly more positive than Right Anterior [ $F(1,8) = 20.672$ ;  $p < .002$ ] and Left Anterior [ $F(1,8) = 26.613$ ;  $p < .001$ ], and that Right Posterior was significantly more positive than Right Anterior [ $F(1,8) = 30.678$ ;  $p < .001$ ] and Left Anterior [ $F(1,8) = 18.549$ ;  $p < .003$ ]. However, the difference between both posterior regions failed to reach statistical significance [ $F(1,8) = 3.103$ ;  $p < .116$ ].

The grammaticality by region interaction failed to reach statistical significance in the omnibus ANOVA [ $F(1.759, 14.074) = 3.014$ ;  $p < .086$ ] after applying the Greenhouse-Geisser test to correct for a potential violation of the sphericity assumption.

#### **7.2.2.2.2. Experiment 2**

A significant main effect of grammaticality was found in the omnibus ANOVA [ $F(2,16) = 12.625$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 19.443$ ;  $p < .002$ ] and gender agreement violations [ $F(1,8) = 14.828$ ;  $p < .005$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .34$ ;  $p < .859$ ].

A significant main effect of region was found in the omnibus ANOVA [ $F(1.84, 14.72) = 4.078$ ;  $p < .042$ ] after applying the Greenhouse-Geisser test to correct for a potential violation of the sphericity assumption. Post-hoc tests indicated that Left



Posterior was significantly more positive than Left Anterior [ $F(1,8) = 7.678$ ;  $p < .024$ ]. All other contrasts failed to reach statistical significance.

The grammaticality by region interaction failed to reach statistical significance in the omnibus ANOVA [ $F(2.215, 17.717) = 1.620$ ;  $p < .225$ ] after applying the Greenhouse-Geisser test to correct for a potential violation of the sphericity assumption.

### **7.2.2.2.3. Experiment 3**

A significant main effect of grammaticality was found in the omnibus ANOVA [ $F(2,16) = 17.951$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 22.839$ ;  $p < .001$ ] and gender agreement violations [ $F(1,8) = 20.745$ ;  $p < .002$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .317$ ;  $p < .589$ ].

There was no significant main effect of region in the omnibus ANOVA [ $F(1.866, 14.931) = 2.488$ ;  $p < .119$ ] after applying the Greenhouse-Geisser test to correct for a potential violation of the sphericity assumption.

Likewise, the grammaticality by region interaction failed to reach statistical significance in the omnibus ANOVA [ $F(2.062, 16.497) = .325$ ;  $p < .734$ ] after applying the Greenhouse-Geisser test to correct for a potential violation of the sphericity assumption.

### **7.2.2.3. P600 (650-900ms)**

Based on the results of the t-tests, a series of two-way repeated measures ANOVAs was conducted in order to investigate a potential interaction between factors grammaticality and region (3 x 4) in the 650-900ms time-window.

### **7.2.2.3.1. Experiment 1**

The omnibus ANOVA revealed no significant main effect of grammaticality [ $F(2,16) = 2.429$ ;  $p < .120$ ].

A significant main effect of region was found in the omnibus ANOVA [ $F(1.207, 9.657) = 31.830$ ;  $p < .001$ ] after applying the Greenhouse-Geisser test to correct for a potential violation of the sphericity assumption. Post-hoc tests indicated that Left Posterior was significantly more positive than Right Anterior [ $F(1,8) = 45.927$ ;  $p < .002$ ] and Left Anterior [ $F(1,8) = 41.845$ ;  $p < .001$ ], and that Right Posterior was significantly more positive than Right Anterior [ $F(1,8) = 28.814$ ;  $p < .001$ ] and Left Anterior [ $F(1,8) = 24.250$ ;  $p < .001$ ]. However, the difference between both posterior regions failed to reach statistical significance [ $F(1,8) = 4.383$ ;  $p < .07$ ].

A significant grammaticality by region interaction was found in the omnibus ANOVA [ $F(2.172, 17.375) = 8.435$ ;  $p < .002$ ] after applying the Greenhouse-Geisser test to correct for a potential violation of the sphericity assumption. The interaction was driven by the fact that both posterior regions became more positive when an agreement violation was detected, but Right Anterior remained relatively unaffected and Left Anterior became slightly more negative for number agreement violations and even more so for gender agreement violations.

### **7.2.2.3.2. Experiment 2**

The omnibus ANOVA revealed no significant main effect of grammaticality [ $F(2,16) = 1.879$ ;  $p < .185$ ].

A significant main effect of region was found in the omnibus ANOVA [ $F(1.418, 11.345) = 8.899$ ;  $p < .008$ ] after applying the Greenhouse-Geisser test to correct for a potential violation of the sphericity assumption. Post-hoc tests indicated that Left

Posterior was significantly more positive than Right Anterior [ $F(1,8) = 8.025$ ;  $p < .022$ ] and Left Anterior [ $F(1,8) = 11.030$ ;  $p < .011$ ], and that Right Posterior was significantly more positive than Right Anterior [ $F(1,8) = 8.927$ ;  $p < .017$ ] and Left Anterior [ $F(1,8) = 10.460$ ;  $p < .012$ ]. However, the difference between both posterior regions failed to reach statistical significance [ $F(1,8) = .480$ ;  $p < .508$ ].

A significant grammaticality by region interaction was found in the omnibus ANOVA [ $F(6, 48) = 13.385$ ;  $p < .001$ ]. The interaction was driven by the fact that both posterior regions became more positive when an agreement violation was detected, but Right Anterior remained relatively unaffected and Left Anterior became slightly more negative for gender agreement violations and more so for number agreement violations.

#### **7.2.2.3.3. Experiment 3**

The omnibus ANOVA revealed no significant main effect of grammaticality [ $F(2,16) = 2.387$ ;  $p < .124$ ].

A significant main effect of region was found in the omnibus ANOVA [ $F(1.593, 12.747) = 6.894$ ;  $p < .013$ ] after applying the Greenhouse-Geisser test to correct for a potential violation of the sphericity assumption. Post-hoc tests indicated that Left Posterior was significantly more positive than Right Anterior [ $F(1,8) = 10.725$ ;  $p < .022$ ] and Left Anterior [ $F(1,8) = 8.062$ ;  $p < .022$ ], and that Right Posterior was significantly more positive than Right Anterior [ $F(1,8) = 8.010$ ;  $p < .022$ ]. However, the difference between Right Posterior and Left Anterior failed to reach statistical significance [ $F(1,8) = 4.465$ ;  $p < .068$ ], as did the difference between both posterior regions [ $F(1,8) = 2.506$ ;  $p < .152$ ].

A significant grammaticality by region interaction was found in the omnibus ANOVA [ $F(2.377, 19.014) = 9.690$ ;  $p < .001$ ]. This interaction was driven by the fact

that both posterior regions became more positive when an agreement mismatch was detected, while both anterior regions became more negative for gender agreement violations, but remained relatively unaffected by number mismatches.

### **7.3. Distance Effects**

In order to examine the effects of syntactic distance on the processing of agreement, we first calculated the effects of the agreement violations in Experiments 1 and 2. For each experiment, the mean amplitude of the grammatical condition was subtracted from the mean amplitude of the number agreement violations. We will call the output of this computation “the number effect”. The same subtraction was performed with gender agreement violations, to calculate “the gender effect”. This analysis was computed for the second phase of the P600 (650-900ms time window), which is the time window where Barber & Carreiras (2005) predict differences between agreement violations within and across phrases (a more positive effect for across-phrase violations).

As the second phase of the P600 traditionally has a parietal distribution, it was decided to examine the effects of syntactic distance at the region level, in order to investigate a potential interaction between region and distance.

#### **7.3.1. Analyses on Regions of Interest**

The same regions of interest described in section 7.2.2 were created in order to investigate a potential interaction between distance and the topography of the effects. The value of each region of interest was computed by averaging the value of the subtractions (disagreement minus agreement) of all the electrodes in the region.

A series of t-tests was performed to compare the number effect (number disagreement minus agreement) in Experiment 1 (within-phrase agreement) to the

number effect in Experiment 2 (across-phrase agreement). The same analysis was then carried out for gender agreement violations.

The results of the t-tests revealed no significant effects ( $p < .05$ ) of syntactic distance for either violation type in any of the regions of interest. Despite the lack of significant effects in the t-tests, it was decided to conduct a three-way repeated measures ANOVA in order to examine a potential interaction between the factors agreement type, region, and distance (2 x 4 x 2).

There was no significant main effect of agreement type [ $F(1,8) = .194$ ;  $p < .672$ ] or distance [ $F(1,8) = .051$ ;  $p < .827$ ]. In addition, there was no significant interaction between agreement type and region [ $F(3,24) = 1.384$ ;  $p < .272$ ], agreement type and distance [ $F(1,8) = 2.136$ ;  $p < .182$ ], region and distance [ $F(1.643, 13.143) = 1.288$ ;  $p < .301$ ], or agreement type, region, and distance [ $F(3,24) = 2.204$ ;  $p < .114$ ].<sup>41</sup> However, a significant main effect of region was found in the omnibus ANOVA [ $F(3,24) = 18.314$ ;  $p < .001$ ], suggesting that Right Posterior was significantly more positive than both Right Anterior [ $F(1,8) = 11.126$ ;  $p < .01$ ] and Left Anterior [ $F(1,8) = 50.788$ ;  $p < .001$ ], and that Left Posterior was significantly more positive than Left Anterior [ $F(1,8) = 35.188$ ;  $p < .001$ ]. All other contrasts failed to reach significance. In sum, neither the t-tests nor the three-way ANOVA revealed an effect of syntactic distance on the processing of agreement violations in the 650-900ms time window. For its part, the main effect of region shown by the ANOVA suggests that the second phase of the P600 was mainly posteriorly distributed, independently of agreement type and distance.

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<sup>41</sup> The analysis for the region by distance interaction was carried out after applying the Greenhouse-Geisser test to correct for a potential violation of the sphericity assumption.

#### 7.4. Number vs. Gender

In order to investigate potential differences between agreement types, we first calculated the number and gender effects separately, in all three experiments.<sup>42</sup> This analysis was computed (following the same procedure described in section 7.3) for the second phase of the P600 (650-900ms time window), which is when Barber & Carreiras (2005) predict differences between number and gender (a more positive wave for gender than for number agreement violations).

A three-way repeated measures ANOVA was conducted, including the factors agreement type, region, and experiment (2 x 4 x 3). The results of the ANOVA revealed no significant main effect of agreement type [ $F(1,8) = .524$ ;  $p < .490$ ] or experiment [ $F(2,16) = .038$ ;  $p < .962$ ]. However, a significant main effect of region was found [ $F(3,24) = 19.707$ ;  $p < .001$ ]. Post-hoc tests indicated that Left Posterior was significantly more positive than both Left Anterior [ $F(1,8) = 35.024$ ;  $p < .001$ ] and Right Anterior [ $F(1,8) = 6.482$ ;  $p < .034$ ], and that Right Posterior was significantly more positive than Left Anterior [ $F(1,8) = 45.212$ ;  $p < .001$ ] and Right Anterior [ $F(1,8) = 14.126$ ;  $p < .006$ ]. Moreover, the difference between both anterior regions reached statistical significance [ $F(1,8) = 9.266$ ;  $p < .016$ ], but the difference between both posterior regions did not [ $F(1,8) = 4.04$ ;  $p < .079$ ].

In addition, there was no significant interaction between agreement type and experiment [ $F(1.098, 8.785) = 1.851$ ;  $p < .189$ ] or between agreement type, region, and experiment [ $F(2.448, 19.587) = 2.009$ ;  $p < .071$ ]. However, a significant agreement type by region interaction was found in the omnibus ANOVA [ $F(3,24) = 3.351$ ;  $p < .036$ ], suggesting that the anterior regions were less positive for gender agreement violations than for number agreement violations.

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<sup>42</sup> Number disagreement minus agreement, and gender disagreement minus agreement.

## 8. Discussion

The present study was designed to investigate a series of questions raised by Barber & Carreiras (2005) on the electrophysiological processing of number and gender agreement in Spanish. Those questions, which were presented in the introduction and in Section 5, are repeated below for ease of reading:

- 1) What electrophysiological effects do violations of number and gender agreement in Spanish elicit, when measured on a target of agreement (adjective)? What effects do they elicit when measured on an agreement trigger (noun)?
- 2) Are there any differences in the electrophysiological processing of number and gender agreement in Spanish?
- 3) Does syntactic distance affect the electrophysiological processing of agreement—regardless of agreement category—when linear distance is controlled for? Is agreement costlier when the agreeing elements are located across phrases?

As far as the first question is concerned (the electrophysiological correlates of agreement violations in Spanish), our predictions were based both on Friederici's model of auditory sentence processing (Friederici, 2002) and on the results of a previous ERP investigation by Barber & Carreiras (2005). Friederici's model of sentence processing posits that morphosyntactic information (i.e., agreement) is integrated into an incoming sentence between 300 and 500ms. Under Friederici's account, failure to integrate morphosyntactic information yields a Left Anterior Negativity (LAN), a negative deflection captured by the left anterior electrodes between 300 and 500ms. Another prediction by Friederici's model is that the parser's attempt to repair a morphosyntactic violation will trigger a positive wave approximately between 500 and 900ms and with a centro-posterior distribution.

Given that the agreement violations in the present study fit within Friederici's description of a morphosyntactic mismatch, our first prediction was that both number agreement violations and gender agreement violations should yield a LAN and a P600 in all three experiments. This prediction was also in line with Barber & Carreiras (2005), who reported both a LAN and a P600 for number agreement violations and gender agreement violations in sentential contexts in Spanish, all of which involved the most canonical morphemes associated with number and gender, as in the present study.

As far as the Left Anterior Negativity is concerned, we did not find a consistent LAN-effect in any of the two time windows considered (150-400ms and 250-400ms). This was true for both types of analyses (on single electrodes and on regions of interest). The analysis on single electrodes revealed that none of the 32 electrodes consistently showed a LAN-effect for both number agreement violations and gender agreement violations in all three experiments. Likewise, the analysis on regions of interest indicated that none of the four regions of interest, including the one canonically associated with the LAN (Left Anterior), showed a LAN-effect for both number agreement violations and gender mismatches in all three experiments.

Therefore, our results do not support Friederici's claim that the Left Anterior Negativity reflects failure to perform morphosyntactic integration. If that were the case, agreement violations in the present study should have elicited this component in all three experiments and regardless of agreement type, a pattern which we did not find. Our results are also in disagreement with Barber & Carreiras (2005), who reported a LAN for both number mismatches and gender agreement violations in Spanish using stimuli that were very similar to the ones in the present study. However, our results are in line with a significant number of previous studies that did not report a Left Anterior Negativity for agreement violations, notably Wicha et al. (2003) and (2004) and Martín-



Loeches et al. (2006) in Spanish; Hagoort & Brown (1999) and Hagoort (2003) in Dutch; Deutsch & Bentin (2001) in Hebrew; and Schmitt et al. (2002) in German. The fact that no consistent LAN was found in our study only confirms that the real nature of this component is more complex than originally proposed by Friederici.<sup>43</sup>

In line with our predictions, agreement violations in Spanish elicited very robust P600 effects in all three experiments, a finding that was consistent across analysis type. The single electrode analysis revealed systematic P600 effects in various centro-posterior electrodes for violations of both agreement types in all three experiments. Likewise, the analysis on regions of interest revealed P600s with a posterior distribution for both number agreement violations and gender agreement violations in all three experiments.<sup>44</sup> These findings suggest that the P600 can be taken as a strong neural correlate of agreement processing, especially as it was consistently found for violations of both agreement categories, regardless of the syntactic distance between the agreeing elements (Experiment 1 vs. Experiment 2) and regardless of the syntactic category of the critical word (Experiments 1 and 2 vs. Experiment 3). In this respect, it must be pointed out that a comparison of the P600-effects for agreement violations detected on agreement targets vs. agreement triggers (Experiments 1 and 2 vs. Experiment 3) revealed no differences. The only difference we found concerned the topography of the P600, with region Right Posterior being involved in violations detected an agreement targets, but not triggers. This suggests that, in sentential contexts, agreement is

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<sup>43</sup> Furthermore, given that both of the agreeing elements in every experiment of the present study exhibited canonical number morphology (plural *-s*) and gender markers (masculine *-o* or feminine *-a*), our results do not support the view that the Left Anterior Negativity is triggered by failure to match overt morphological features (i.e., matching *-o* in the noun with *-o* in the adjective), as suggested by Hagoort & Brown, 1999.

<sup>44</sup> Region Left Posterior was significantly more positive than both anterior regions in all three Experiments. By contrast, Right Posterior was only significantly more positive than both anterior regions in Experiments 1 and 2. Our data suggest that, in general, the effect has a posterior distribution, although it may not be consistently bilateral, which is in line with previous accounts on the morphology of the P600 (i.e., Kaan, 2002; Wicha et al., 2004).

processed in a rather homogenous way (as a syntactic process) regardless of the syntactic category of the critical word.

Our results are consistent with all previous studies investigating the electrophysiological processing of agreement in Spanish (Barber & Carreiras, 2005; Martín Loeches et al., 2006; Wicha et al., 2004; Wicha et al., 2003) and in other related and non-related languages (English: Osterhout & Mobley, 1995; Osterhout et al., 1997; Dutch: Hagoort & Brown, 1999; Hagoort, 2003; Hebrew: Deutsch & Bentin, 2001; German: Schmitt et al., 2002; Günter et al., 2000; Rossi et al., 2005; Italian: De Vincenzi et al., 2003; Molinaro et al., 2008), all of which reported a P600. Furthermore, in line with Hagoort & Brown's proposal (2000) and with Barber & Carreiras' findings (2005), the P600 in the present study can also be decomposed into an early phase (400-650ms) and a late phase (650-900ms) showing different topographical distributions. This is particularly obvious in the single electrode analysis (Figure 5, page 85; Figure 6, page 88), where it can be seen that the early phase of the P600 (400-650ms) is broadly distributed and even includes some electrodes from the frontal regions, while the late P600 (650-900ms) exhibits a much more restricted distribution, one that is almost limited to parietal electrodes.<sup>45</sup> The analysis on regions of interest provides further evidence that the early and late phases of the P600 display different topographical distributions, as suggested by the consistent lack of an interaction between region and grammaticality in the early phase of the P600 (all regions became more positive for agreement violations), and by the consistent presence of a region by grammaticality interaction in the late phase of the P600 (only the posterior regions became more positive in the presence of an agreement violation). This finding is all the more relevant

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<sup>45</sup> It must be pointed out that, even though the early phase of the P600 recruits a rather broad array of electrodes from the four regions, it is mainly posteriorly distributed.

as it allows us to better address research questions 2 and 3, both of which assume a late P600 with a different topographical distribution from that of the early P600.

So far as the second research question is concerned (differences in the electrophysiological processing of number and gender agreement), our predictions were based on Barber & Carreiras (2005), who found that the late phase of the P600 exhibited greater amplitude for gender agreement violations than for number agreement violations. The late phase of the P600 being associated with repair, Barber & Carreiras interpret this finding as evidence that gender agreement violations are costlier to repair than number mismatches, as the parser must go back to the earliest stage of lexical processing (lexical identification) to check for gender information.

Based on Barber & Carreiras, our prediction for the present study was that, if gender agreement violations truly show greater amplitude than number disagreements in the late phase of the P600, there should be a significant interaction between agreement type and region such that the posterior regions would be more positive for the gender effect (gender disagreement minus grammatical) than for the number effect (number disagreement minus grammatical). For their part, the anterior regions, which are not recruited in the late phase of the P600, should remain relatively unaffected. Our results clearly do not support this hypothesis. Although there was an agreement type by region interaction, the nature of the interaction did not go in the predicted direction. In the first place, both posterior regions were unaffected by agreement type. In addition, both anterior regions, which are not recruited in the second phase of the P600, were more positive for number agreement violations than for gender mismatches, an effect that is not in line with Barber & Carreiras (2005).

Assuming that we can use the late phase of the P600 to test theoretical proposals about the syntax of number and gender, our results are in contradiction with Barber &

Carreiras' evidence that number is essentially a syntactic head and gender, a lexical property of nouns. Recall that Barber & Carreiras (2005) interpret the greater late P600 for gender agreement violations in their study as an indication that—unlike number, which projects its own phrase in the syntax—gender is a lexical property of nouns and, therefore, a gender agreement violation forces the parser to go back to the earliest stage of lexical retrieval to check for gender information. In the present study, we found that the late P600 was similar for both number and gender agreement violations, suggesting that both features may actually be represented in a similar way, more in line with the proposal by Picallo (1991) that both number and gender project their own phrase. Therefore, when the parser encounters either a number agreement violation or a gender agreement violation, it goes back to the same lexical retrieval stage (integration) to repair them.

That no differences between number and gender agreement violations were found in the late phase of the P600 does not necessarily imply that these two features are processed identically. The present study was designed to put to the test some of the claims made in Barber & Carreiras (2005) and, therefore, our analysis focused on the late phase of the P600. However, it must be pointed out that differences between the processing of these two features might have emerged at a different level of analysis. For example, in the single electrode analysis, it was observed that some electrodes showed a consistent P600 effect for gender agreement violations but not for number agreement violations (and vice versa).<sup>46</sup> Those electrodes were discarded from the present study, as our main hypothesis concerns differences in how number disagreement and gender disagreement affect the morphology of the P600 and, therefore, a consistent P600 is required to start with. However, those differences at the electrode level are interesting

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<sup>46</sup> In these cases, the P600 effect for number agreement violations would be found in two out of the three experiments. It was never the case that an electrode consistently showed a P600 effect for one agreement type and never for the other.

*per se* and they represent a starting point to further investigate differences between number and gender agreement.

Finally, as far as the third research question is concerned (the effects of syntactic distance on the electrophysiological processing of agreement), our predictions were also based on Barber & Carreiras (2005), who found that the late phase of the P600 exhibited greater amplitude when the agreement violations were located across a VP than when they were local (within the DP). As the late phase of the P600 is assumed to reflect repair processes, Barber & Carreiras posit that repairing agreement violations across phrases may require greater resources than repairing agreement violations within the same phrase, as the parser must cross a phrase boundary to check for agreement.<sup>47</sup>

Based on Barber & Carreiras, our prediction for the current study was as follows: if across-phrase agreement violations truly show greater amplitude in the late phase of the P600 than within-phrase agreement violations, there should be a distance by region interaction such that the posterior regions would become more positive for violations across the phrase than for violations within the phrase. For their part, the anterior regions, which are not recruited in the late phase of the P600, should remain relatively unaffected. Our results do not support this hypothesis either. Although there was a significant main effect of region (both posterior regions were more positive than the anterior regions), the analysis revealed no distance by region interaction, due to the fact that both Left Posterior and Right Posterior, which are the regions recruited in the late phase of the P600, were unaffected by the syntactic distance between the agreeing elements.<sup>48</sup>

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<sup>47</sup> As pointed out earlier, a concern with Barber & Carreiras is that syntactic distance and linear distance were confounded in their stimuli, a problem that was corrected in the present study.

<sup>48</sup> For their part, the anterior regions were also unaffected by the distance manipulation, suggesting that the lack of distance effects was consistent across regions.

Our results are more in line with Kaan (2002), who reported no differences in P600 amplitude for short versus long distance subject-verb number agreement violations in Dutch, and with Vos et al. (2001), who also reported no differences in P600 amplitude between low and high complexity sentences involving subject-verb number agreement violations in Dutch.<sup>49</sup> We will continue to investigate potential effects of syntactic distance on the processing of agreement as we increase the sample size in the study.

In sum, the results of the present study are in line with a significant number of previous ERP studies on the processing of agreement that found a P600 but not a LAN. As to research question 2, the present study found no evidence for differences in the processing of number and gender agreement. Finally, as far as research question 3 is concerned, we found no significant amplitude differences between within and across-phrase agreement violations in the second phase of the P600 (650-900ms).

## **9. Conclusion**

The present study investigated the electrophysiological processing of number and gender agreement in Spanish and how it is affected by the syntactic distance between the agreeing elements. In line with a number of previous ERP studies on agreement, our results suggest that agreement violations in Spanish are invariably associated with a posteriorly-distributed P600 (a neural index of syntactic repair), but not with a Left Anterior Negativity, a component that has been argued to reflect the detection of morphosyntactic violations. Furthermore, we found no evidence in our investigation for a differential treatment of number and gender at the electrophysiological level, as violations of both agreement types yielded very similar effects, suggesting that these two features may actually be processed similarly. Finally, we also found no evidence

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<sup>49</sup> However, complexity effects were found in the LAN in Vos et al. (2001), which showed decreased amplitude for more complex sentences.

that agreement processes may be impacted by syntactic distance (as indexed by the late phase of the P600) when linear distance is controlled for, as agreement violations within the DP and across the VP also yielded similar results in our study. As this study in progress continues and the sample size increases (currently,  $n = 9$ ), we will further investigate the different outcomes between the present study and previous neurophysiological investigations of number and gender agreement.

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## APPENDIX 1: Stimuli in Experiment 1

1. El Índico es un océano muy profundo y el Pacífico también.
2. El Índico es un océano muy \*profundos y el Pacífico también.
3. El Índico es un océano muy \*profunda y el Pacífico también.
  
4. El Antártico es un océano muy frío y el Ártico también.
5. El Antártico es un océano muy \*fríos y el Ártico también.
6. El Antártico es un océano muy \*fría y el Ártico también.
  
7. La pimienta es una especia muy usada y la páprika también.
8. La pimienta es una especia muy \*usadas y la páprika también.
9. La pimienta es una especia muy \*usado y la páprika también.
  
10. La canela es una especia muy exótica y la cayena también.
11. La canela es una especia muy \*exóticas y la cayena también.
12. La canela es una especia muy \*exótico y la cayena también.
  
13. El bocadillo es un aperitivo muy alimenticio y el gazpacho también.
14. El bocadillo es un aperitivo muy \*alimenticios y el gazpacho también.
15. El bocadillo es un aperitivo muy \*alimenticia y el gazpacho también.
  
16. El queso es un aperitivo muy graso y el chorizo también.
17. El queso es un aperitivo muy \*grasos y el chorizo también.
18. El queso es un aperitivo muy \*grasa y el chorizo también.
  
19. La lechuga es una verdura muy insípida y la escarola también.
20. La lechuga es una verdura muy \*insípidas y la escarola también.
21. La lechuga es una verdura muy \*insípido y la escarola también.
  
22. La espinaca es una verdura muy sana y la cebolla también.
23. La espinaca es una verdura muy \*sanas y la cebolla también.
24. La espinaca es una verdura muy \*sano y la cebolla también.
  
25. El cementerio es un recinto muy sombrío y el mausoleo también.
26. El cementerio es un recinto muy \*sombrios y el mausoleo también.
27. El cementerio es un recinto muy \*sombria y el mausoleo también.
  
28. El monasterio es un recinto muy silencioso y el asilo también.
29. El monasterio es un recinto muy \*silenciosos y el asilo también.
30. El monasterio es un recinto muy \*silenciosa y el asilo también.
  
31. La hamburguesa es una comida muy nutritiva y la salchicha también.
32. La hamburguesa es una comida muy \*nutritivas y la salchicha también.
33. La hamburguesa es una comida muy \*nutritivo y la salchicha también.
  
34. La pizza es una comida muy apetitosa y la tortilla también.
35. La pizza es una comida muy \*apetitosas y la tortilla también.
36. La pizza es una comida muy \*apetitoso y la tortilla también.

37. El rojo es un tono muy intenso y el negro también.  
 38. El rojo es un tono muy \*intensos y el negro también.  
 39. El rojo es un tono muy \*intensa y el negro también.
40. El amarillo es un tono muy luminoso y el blanco también.  
 41. El amarillo es un tono muy \*luminosos y el blanco también.  
 42. El amarillo es un tono muy \*luminosa y el blanco también.
43. La esmeralda es una piedra muy valiosa y la aguamarina también.  
 44. La esmeralda es una piedra muy \*valiosas y la aguamarina también.  
 45. La esmeralda es una piedra muy \*valioso y la aguamarina también.
46. La turquesa es una piedra muy hermosa y la amatista también.  
 47. La turquesa es una piedra muy \*hermosas y la amatista también.  
 48. La turquesa es una piedra muy \*hermoso y la amatista también.
49. El pescado es un alimento muy nutritivo y el marisco también.  
 50. El pescado es un alimento muy \*nutritivos y el marisco también.  
 51. El pescado es un alimento muy \*nutritiva y el marisco también.
52. El pepino es un alimento muy insípido y el espárrago también.  
 53. El pepino es un alimento muy \*insípidos y el espárrago también.  
 54. El pepino es un alimento muy \*insípida y el espárrago también.
55. La cerveza es una bebida muy amarga y la tónica también.  
 56. La cerveza es una bebida muy \*amargas y la tónica también.  
 57. La cerveza es una bebida muy \*amargo y la tónica también.
58. La sangría es una bebida muy fresca y la limonada también.  
 59. La sangría es una bebida muy \*frescas y la limonada también.  
 60. La sangría es una bebida muy \*fresco y la limonada también.
61. El termómetro es un invento muy práctico y el barómetro también.  
 62. El termómetro es un invento muy \*prácticos y el barómetro también.  
 63. El termómetro es un invento muy \*práctica y el barómetro también.
64. El microscopio es un invento muy caro y el telescopio también.  
 65. El microscopio es un invento muy \*caros y el telescopio también.  
 66. El microscopio es un invento muy \*cara y el telescopio también.
67. La selva es una zona muy exótica y la playa también.  
 68. La selva es una zona muy \*exóticas y la playa también.  
 69. La selva es una zona muy \*exótico y la playa también.
70. La costa es una zona muy húmeda y la jungla también.  
 71. La costa es una zona muy \*húmedas y la jungla también.  
 72. La costa es una zona muy \*húmedo y la jungla también.

73. El baloncesto es un juego muy entretenido y el taekwondo también.  
 74. El baloncesto es un juego muy \*entretenidos y el taekwondo también.  
 75. El baloncesto es un juego muy \*entretenida y el taekwondo también.
76. El polo es un juego muy aburrido y el dominó también.  
 77. El polo es un juego muy \*aburridos y el dominó también.  
 78. El polo es un juego muy \*aburrida y el dominó también.
79. La seda es una tela muy fina y la alpaca también.  
 80. La seda es una tela muy \*finas y la alpaca también.  
 81. La seda es una tela muy \*fino y la alpaca también.
82. La lana es una tela muy cálida y la angora también.  
 83. La lana es una tela muy \*cálidas y la angora también.  
 84. La lana es una tela muy \*cálido y la angora también.
85. El santuario es un templo muy silencioso y el convento también.  
 86. El santuario es un templo muy \*silenciosos y el convento también.  
 87. El santuario es un templo muy \*silenciosa y el convento también.
88. El Vaticano es un templo muy simbólico y el Elíseo también.  
 89. El Vaticano es un templo muy \*simbólicos y el Elíseo también.  
 90. El Vaticano es un templo muy \*simbólica y el Elíseo también.
91. La camiseta es una prenda muy cómoda y la camisa también.  
 92. La camiseta es una prenda muy \*cómodas y la camisa también.  
 93. La camiseta es una prenda muy \*cómodo y la camisa también.
94. La chaqueta es una prenda muy usada y la bufanda también.  
 95. La chaqueta es una prenda muy \*usadas y la bufanda también.  
 96. La chaqueta es una prenda muy \*usado y la bufanda también.
97. El aeropuerto es un sitio muy ruidoso y el puerto también.  
 98. El aeropuerto es un sitio muy \*ruidosos y el puerto también.  
 99. El aeropuerto es un sitio muy \*ruidosa y el puerto también.
100. El reformatorio es un sitio muy peligroso y el presidio también.  
 101. El reformatorio es un sitio muy \*peligrosos y el presidio también.  
 102. El reformatorio es un sitio muy \*peligrosa y el presidio también.
103. La menta es una hierba muy aromática y la albahaca también.  
 104. La menta es una hierba muy \*aromáticas y la albahaca también.  
 105. La menta es una hierba muy \*aromáticos y la albahaca también.
106. La camomila es una hierba muy curativa y la melisa también.  
 107. La camomila es una hierba muy \*curativas y la melisa también.  
 108. La camomila es una hierba muy \*curativo y la melisa también.

109. El helicóptero es un medio muy seguro y el aeroplano también.  
 110. El helicóptero es un medio muy \*seguros y el aeroplano también.  
 111. El helicóptero es un medio muy \*segura y el aeroplano también.
112. El metro es un medio muy barato y el barco también.  
 113. El metro es un medio muy \*baratos y el barco también.  
 114. El metro es un medio muy \*barata y el barco también.
115. La manzana es una fruta muy jugosa y la papaya también.  
 116. La manzana es una fruta muy \*jugosas y la papaya también.  
 117. La manzana es una fruta muy \*jugoso y la papaya también.
118. La frambuesa es una fruta muy ácida y la lima también.  
 119. La frambuesa es una fruta muy \*ácidas y la lima también.  
 120. La frambuesa es una fruta muy \*ácido y la lima también.
121. El vaso es un utensilio muy barato y el cuenco también.  
 122. El vaso es un utensilio muy \*baratos y el cuenco también.  
 123. El vaso es un utensilio muy \*barata y el cuenco también.
124. El cuchillo es un utensilio muy afilado y el martillo también.  
 125. El cuchillo es un utensilio muy \*afilados y el martillo también.  
 126. El cuchillo es un utensilio muy \*afilada y el martillo también.
127. La física es una ciencia muy precisa y la química también.  
 128. La física es una ciencia muy \*precisas y la química también.  
 129. La física es una ciencia muy \*preciso y la química también.
130. La psicología es una ciencia muy compleja y la lingüística también.  
 131. La psicología es una ciencia muy \*complejas y la lingüística también.  
 132. La psicología es una ciencia muy \*complejo y la lingüística también.
133. El exorcismo es un rito muy serio y el entierro también.  
 134. El exorcismo es un rito muy \*serios y el entierro también.  
 135. El exorcismo es un rito muy \*seria y el entierro también.
136. El matrimonio es un rito muy festivo y el bautismo también.  
 137. El matrimonio es un rito muy \*festivos y el bautismo también.  
 138. El matrimonio es un rito muy \*festiva y el bautismo también.
139. La plata es una joya muy hermosa y la malaquita también.  
 140. La plata es una joya muy \*hermosas y la malaquita también.  
 141. La plata es una joya muy \*hermoso y la malaquita también.
142. La perla es una joya muy cara y la turmalina también.  
 143. La perla es una joya muy \*caras y la turmalina también.  
 144. La perla es una joya muy \*caro y la turmalina también.



145. El vídeo es un aparato muy práctico y el teléfono también.  
 146. El vídeo es un aparato muy \*prácticos y el teléfono también.  
 147. El vídeo es un aparato muy \*práctica y el teléfono también.
148. El frigorífico es un aparato muy espacioso y el horno también.  
 149. El frigorífico es un aparato muy \*espaciosos y el horno también.  
 150. El frigorífico es un aparato muy \*espaciosa y el horno también.
151. La peseta es una moneda muy prestigiosa y la lira también.  
 152. La peseta es una moneda muy \*prestigiosas y la lira también.  
 153. La peseta es una moneda muy \*prestigioso y la lira también.
154. La libra es una moneda muy valiosa y la rupia también.  
 155. La libra es una moneda muy \*valiosas y la rupia también.  
 156. La libra es una moneda muy \*valioso y la rupia también.
157. El cerebro es un órgano muy complejo y el cerebelo también.  
 158. El cerebro es un órgano muy \*complejos y el cerebelo también.  
 159. El cerebro es un órgano muy \*compleja y el cerebelo también.
160. El estómago es un órgano muy delicado y el hígado también.  
 161. El estómago es un órgano muy \*delicados y el hígado también.  
 162. El estómago es un órgano muy \*delicada y el hígado también.
163. La ensalada es una cena muy fresca y la pasta también.  
 164. La ensalada es una cena muy \*frescas y la pasta también.  
 165. La ensalada es una cena muy \*fresco y la pasta también.
166. La sopa es una cena muy ligera y la patata también.  
 167. La sopa es una cena muy \*ligeras y la patata también.  
 168. La sopa es una cena muy \*ligero y la patata también.
169. El odio es un sentimiento muy doloroso y el enojo también.  
 170. El odio es un sentimiento muy \*dolorosos y el enojo también.  
 171. El odio es un sentimiento muy \*dolorosa y el enojo también.
172. El orgullo es un sentimiento muy primitivo y el deseo también.  
 173. El orgullo es un sentimiento muy \*primitivos y el deseo también.  
 174. El orgullo es un sentimiento muy \*primitiva y el deseo también.
175. La paella es una receta muy elaborada y la empanada también.  
 176. La paella es una receta muy \*elaboradas y la empanada también.  
 177. La paella es una receta muy \*elaborado y la empanada también.
178. La lasaña es una receta muy sencilla y la enchilada también.  
 179. La lasaña es una receta muy \*sencillas y la enchilada también.  
 180. La lasaña es una receta muy \*sencillo y la enchilada también.

181. El teatro es un espectáculo muy pedagógico y el circo también.  
 182. El teatro es un espectáculo muy \*pedagógicos y el circo también.  
 183. El teatro es un espectáculo muy \*pedagógica y el circo también.
184. El boxeo es un espectáculo muy agresivo y el sumo también.  
 185. El boxeo es un espectáculo muy \*agresivos y el sumo también.  
 186. El boxeo es un espectáculo muy \*agresiva y el sumo también.
187. La malaria es una epidemia muy dañina y la bilharzia también.  
 188. La malaria es una epidemia muy \*dañinas y la bilharzia también.  
 189. La malaria es una epidemia muy \*dañino y la bilharzia también.
190. La difteria es una epidemia muy destructiva y la viruela también.  
 191. La difteria es una epidemia muy \*destructivas y la viruela también.  
 192. La difteria es una epidemia muy \*destructivo y la viruela también.
193. El atletismo es un pasatiempo muy monótono y el remo también.  
 194. El atletismo es un pasatiempo muy \*monótonos y el remo también.  
 195. El atletismo es un pasatiempo muy \*monótona y el remo también.
196. El ciclismo es un pasatiempo muy divertido y el senderismo también.  
 197. El ciclismo es un pasatiempo muy \*divertidos y el senderismo también.  
 198. El ciclismo es un pasatiempo muy \*divertida y el senderismo también.
199. La prehistoria es una época muy misteriosa y la Reconquista también.  
 200. La prehistoria es una época muy \*misteriosas y la Reconquista también.  
 201. La prehistoria es una época muy \*misterioso y la Reconquista también.
202. La infancia es una época muy formativa y la adolescencia también.  
 203. La infancia es una época muy \*formativas y la adolescencia también.  
 204. La infancia es una época muy \*formativo y la adolescencia también.
205. El parmesano es un producto muy graso y el tocino también.  
 206. El parmesano es un producto muy \*grasos y el tocino también.  
 207. El parmesano es un producto muy \*grasa y el tocino también.
208. El cacao es un producto muy amargo y el comino también.  
 209. El cacao es un producto muy \*amargos y el comino también.  
 210. El cacao es un producto muy \*amarga y el comino también.
211. La Provenza es una provincia muy florida y la Toscana también.  
 212. La Provenza es una provincia muy \*floridas y la Toscana también.  
 213. La Provenza es una provincia muy \*florido y la Toscana también.
214. La Borgoña es una provincia muy bonita y la Guyana también.  
 215. La Borgoña es una provincia muy \*bonitas y la Guyana también.  
 216. La Borgoña es una provincia muy \*bonito y la Guyana también.

217. El violonchelo es un instrumento muy sobrio y el chelo también.  
 218. El violonchelo es un instrumento muy \*sobrios y el chelo también.  
 219. El violonchelo es un instrumento muy \*sobria y el chelo también.
220. El piano es un instrumento muy romántico y el clavicordio también.  
 221. El piano es un instrumento muy \*románticos y el clavicordio también.  
 222. El piano es un instrumento muy \*romántica y el clavicordio también.
223. La lavanda es una planta muy curativa y la valeriana también.  
 224. La lavanda es una planta muy \*curativas y la valeriana también.  
 225. La lavanda es una planta muy \*curativo y la valeriana también.
226. La vainilla es una planta muy aromática y la bergamota también.  
 227. La vainilla es una planta muy \*aromáticas y la bergamota también.  
 228. La vainilla es una planta muy \*aromático y la bergamota también.
229. El castillo es un edificio muy sólido y el palacio también.  
 230. El castillo es un edificio muy \*sólidos y el palacio también.  
 231. El castillo es un edificio muy \*sólida y el palacio también.
232. El banco es un edificio muy seguro y el juzgado también.  
 233. El banco es un edificio muy \*seguros y el juzgado también.  
 234. El banco es un edificio muy \*segura y el juzgado también.
235. La mayonesa es una salsa muy sabrosa y la vinagreta también.  
 236. La mayonesa es una salsa muy \*sabrosas y la vinagreta también.  
 237. La mayonesa es una salsa muy \*sabroso y la vinagreta también.
238. La boloñesa es una salsa muy apetitosa y la carbonara también.  
 239. La boloñesa es una salsa muy \*apetitosas y la carbonara también.  
 240. La boloñesa es una salsa muy \*apetitoso y la carbonara también.
241. El mercado es un espacio muy festivo y el casino también.  
 242. El mercado es un espacio muy \*festivos y el casino también.  
 243. El mercado es un espacio muy \*festiva y el casino también.
244. El centro es un espacio muy ruidoso y el ayuntamiento también.  
 245. El centro es un espacio muy \*ruidosos y el ayuntamiento también.  
 246. El centro es un espacio muy \*ruidosa y el ayuntamiento también.
247. La tiranía es una política muy autoritaria y la oligarquía también.  
 248. La tiranía es una política muy \*autoritarias y la oligarquía también.  
 249. La tiranía es una política muy \*autoritario y la oligarquía también.
250. La monarquía es una política muy simbólica y la república también.  
 251. La monarquía es una política muy \*simbólicas y la república también.  
 252. La monarquía es una política muy \*simbólico y la república también.

253. El zumo es un desayuno muy sano y el panecillo también.  
 254. El zumo es un desayuno muy \*sanos y el panecillo también.  
 255. El zumo es un desayuno muy \*sana y el panecillo también.
256. El huevo es un desayuno muy alimenticio y el pomelo también.  
 257. El huevo es un desayuno muy \*alimenticios y el pomelo también.  
 258. El huevo es un desayuno muy \*alimenticia y el pomelo también.
259. La danza es una disciplina muy expresiva y la ópera también.  
 260. La danza es una disciplina muy \*expresivas y la ópera también.  
 261. La danza es una disciplina muy \*expresivo y la ópera también.
262. La gimnasia es una disciplina muy complicada y la hípica también.  
 263. La gimnasia es una disciplina muy \*complicadas y la hípica también.  
 264. La gimnasia es una disciplina muy \*complicado y la hípica también.
265. El asesinato es un delito muy serio y el robo también.  
 266. El asesinato es un delito muy \*serios y el robo también.  
 267. El asesinato es un delito muy \*seria y el robo también.
268. El secuestro es un delito muy violento y el incesto también.  
 269. El secuestro es un delito muy \*violentos y el incesto también.  
 270. El secuestro es un delito muy \*violenta y el incesto también.
271. La lavadora es una máquina muy cómoda y la secadora también.  
 272. La lavadora es una máquina muy \*cómodas y la secadora también.  
 273. La lavadora es una máquina muy \*cómodo y la secadora también.
274. La impresora es una máquina muy buena y la fotocopidora también.  
 275. La impresora es una máquina muy \*buenas y la fotocopidora también.  
 276. La impresora es una máquina muy \*bueno y la fotocopidora también.
277. El impresionismo es un movimiento muy moderno y el surrealismo también.  
 278. El impresionismo es un movimiento muy \*modernos y el surrealismo también.  
 279. El impresionismo es un movimiento muy \*moderna y el surrealismo también.
280. El cubismo es un movimiento muy alternativo y el futurismo también.  
 281. El cubismo es un movimiento muy \*alternativos y el futurismo también.  
 282. El cubismo es un movimiento muy \*alternativa y el futurismo también.
283. La pintura es una técnica muy complicada y la cerámica también.  
 284. La pintura es una técnica muy \*complicadas y la cerámica también.  
 285. La pintura es una técnica muy \*complicado y la cerámica también.
286. La escultura es una técnica muy precisa y la fotografía también.  
 287. La escultura es una técnica muy \*precisas y la fotografía también.  
 288. La escultura es una técnica muy \*preciso y la fotografía también.

289. El turismo es un negocio muy nuevo y el ciberespacio también.  
 290. El turismo es un negocio muy \*nuevos y el ciberespacio también.  
 291. El turismo es un negocio muy \*nueva y el ciberespacio también.
292. El comercio es un negocio muy beneficioso y el petróleo también.  
 293. El comercio es un negocio muy \*beneficiosos y el petróleo también.  
 294. El comercio es un negocio muy \*beneficiosa y el petróleo también.
295. La anemia es una patología muy dañina y la leucemia también.  
 296. La anemia es una patología muy \*dañinas y la leucemia también.  
 297. La anemia es una patología muy \*dañino y la leucemia también.
298. La neumonía es una patología muy dolorosa y la epilepsia también.  
 299. La neumonía es una patología muy \*dolorosas y la epilepsia también.  
 300. La neumonía es una patología muy \*doloroso y la epilepsia también.
301. El Nilo es un río muy largo y el Congo también.  
 302. El Nilo es un río muy \*largos y el Congo también.  
 303. El Nilo es un río muy \*larga y el Congo también.
304. El Orinoco es un río muy profundo y el Duero también.  
 305. El Orinoco es un río muy \*profundos y el Duero también.  
 306. El Orinoco es un río muy \*profunda y el Duero también.
307. La cinematografía es una industria muy nueva y la telefonía también.  
 308. La cinematografía es una industria muy \*nuevas y la telefonía también.  
 309. La cinematografía es una industria muy \*nuevo y la telefonía también.
310. La minería es una industria muy rica y la metalurgia también.  
 311. La minería es una industria muy \*ricas y la metalurgia también.  
 312. La minería es una industria muy \*rico y la metalurgia también.
313. El bolso es un accesorio muy femenino y el abanico también.  
 314. El bolso es un accesorio muy \*femeninos y el abanico también.  
 315. El bolso es un accesorio muy \*femenina y el abanico también.
316. El sombrero es un accesorio muy clásico y el pañuelo también.  
 317. El sombrero es un accesorio muy \*clásicos y el pañuelo también.  
 318. El sombrero es un accesorio muy \*clásica y el pañuelo también.
319. La heroína es una droga muy destructiva y la cocaína también.  
 320. La heroína es una droga muy \*destructoras y la cocaína también.  
 321. La heroína es una droga muy \*destructora y la cocaína también.
322. La nicotina es una droga muy adictiva y la codeína también.  
 323. La nicotina es una droga muy \*adictivas y la codeína también.  
 324. La nicotina es una droga muy \*adictivo y la codeína también.

325. El miedo es un instinto muy humano y el apetito también.  
 326. El miedo es un instinto muy \*humanos y el apetito también.  
 327. El miedo es un instinto muy \*humana y el apetito también.
328. El sexo es un instinto muy primitivo y el pánico también.  
 329. El sexo es un instinto muy \*primitivos y el pánico también.  
 330. El sexo es un instinto muy \*primitiva y el pánico también.
331. La sacarina es una sustancia muy ligera y la fructosa también.  
 332. La sacarina es una sustancia muy \*ligeras y la fructosa también.  
 333. La sacarina es una sustancia muy \*ligero y la fructosa también.
334. La morfina es una sustancia muy adictiva y la cafeína también.  
 335. La morfina es una sustancia muy \*adictivas y la cafeína también.  
 336. La morfina es una sustancia muy \*adictivo y la cafeína también.
337. El cilantro es un condimento muy digestivo y el orégano también.  
 338. El cilantro es un condimento muy \*digestivos y el orégano también.  
 339. El cilantro es un condimento muy \*digestiva y el orégano también.
340. El ajo es un condimento muy sabroso y el romero también.  
 341. El ajo es un condimento muy \*sabrosos y el romero también.  
 342. El ajo es un condimento muy \*sabrosa y el romero también.
343. La biología es una asignatura muy aburrida y la sociología también.  
 344. La biología es una asignatura muy \*aburridas y la sociología también.  
 345. La biología es una asignatura muy \*aburrido y la sociología también.
346. La geografía es una asignatura muy monótona y la teología también.  
 347. La geografía es una asignatura muy \*monótonas y la teología también.  
 348. La geografía es una asignatura muy \*monótono y la teología también.
349. El antibiótico es un medicamento muy bueno y el antidepresivo también.  
 350. El antibiótico es un medicamento muy \*buenos y el antidepresivo también.  
 351. El antibiótico es un medicamento muy \*buena y el antidepresivo también.
352. El antiácido es un medicamento muy agresivo y el antihistamínico también.  
 353. El antiácido es un medicamento muy \*agresivos y el antihistamínico también.  
 354. El antiácido es un medicamento muy \*agresiva y el antihistamínico también.
355. La fábula es una literatura muy elaborada y la poesía también.  
 356. La fábula es una literatura muy \*elaboradas y la poesía también.  
 357. La fábula es una literatura muy \*elaborado y la poesía también.
358. La novela es una literatura muy creativa y la sátira también.  
 359. La novela es una literatura muy \*creativas y la sátira también.  
 360. La novela es una literatura muy \*creativo y la sátira también.

## APPENDIX 2: Stimuli in Experiment 2

1. El Mediterráneo es cálido y el Adriático también.
2. El Mediterráneo es \*cálidos y el Adriático también.
3. El Mediterráneo es \*cálida y el Adriático también.
  
4. El Mediterráneo es tranquilo y el Caspio también.
5. El Mediterráneo es \*tranquilos y el Caspio también.
6. El Mediterráneo es \*tranquila y el Caspio también.
  
7. La Tierra es redonda y la Luna también.
8. La Tierra es \*redondas y la Luna también.
9. La Tierra es \*redondo y la Luna también.
  
10. La Tierra es gigantesca y la atmósfera también.
11. La Tierra es \*gigantescas y la atmósfera también.
12. La Tierra es \*gigantesco y la atmósfera también.
  
13. El colegio es gratuito y el instituto también.
14. El colegio es \*gratuitos y el instituto también.
15. El colegio es \*gratuita y el instituto también.
  
16. El colegio es antiguo y el liceo también.
17. El colegio es \*antiguos y el liceo también.
18. El colegio es \*antigua y el liceo también.
  
19. La isla es preciosa y la bahía también.
20. La isla es \*preciosas y la bahía también.
21. La isla es \*precioso y la bahía también.
  
22. La isla es rocosa y la península también.
23. La isla es \*rocosas y la península también.
24. La isla es \*rocoso y la península también.
  
25. El Coliseo es emblemático y el Foro también.
26. El Coliseo es \*emblemáticos y el Foro también.
27. El Coliseo es \*emblemática y el Foro también.
  
28. El Coliseo es famoso y el Capitolio también.
29. El Coliseo es \*famosos y el Capitolio también.
30. El Coliseo es \*famosa y el Capitolio también.
  
31. La naranja es jugosa y la pera también.
32. La naranja es \*jugosas y la pera también.
33. La naranja es \*jugoso y la pera también.
  
34. La naranja es redonda y la sandía también.
35. La naranja es \*redondas y la sandía también.
36. La naranja es \*redondo y la sandía también.

37. El Atlántico es gigantesco y el Egeo también.
38. El Atlántico es \*gigantescos y el Egeo también.
39. El Atlántico es \*gigantesca y el Egeo también.
  
40. El Atlántico es frío y el Báltico también.
41. El Atlántico es \*fríos y el Báltico también.
42. El Atlántico es \*fría y el Báltico también.
  
43. La falda es femenina y la blusa también.
44. La falda es \*femeninas y la blusa también.
45. La falda es femenino y la blusa también.
  
46. La falda es azulada y la corbata también.
47. La falda es \*azuladas y la corbata también.
48. La falda es \*azulado y la corbata también.
  
49. El faro es grandioso y el obelisco también.
50. El faro es \*grandiosos y el obelisco también.
51. El faro es \*grandiosa y el obelisco también.
  
52. El faro es sólido y el campanario también.
53. El faro es \*sólidos y el campanario también.
54. El faro es \*sólida y el campanario también.
  
55. La casa es minúscula y la cochera también.
56. La casa es \*minúsculas y la cochera también.
57. La casa es \*minúsculo y la cochera también.
  
58. La casa es sombría y la bodega también.
59. La casa es \*sombrías y la bodega también.
60. La casa es \*sombrío y la bodega también.
  
61. El arroyo es hondo y el charco también.
62. El arroyo es \*hondos y el charco también.
63. El arroyo es \*honda y el charco también.
  
64. El arroyo es largo y el meandro también.
65. El arroyo es \*largos y el meandro también.
66. El arroyo es \*larga y el meandro también.
  
67. La cocina es amplia y la entrada también.
68. La cocina es \*amplias y la entrada también.
69. La cocina es \*amplio y la entrada también.
  
70. La cocina es luminosa y la terraza también.
71. La cocina es \*luminosas y la terraza también.
72. La cocina es \*luminoso y la terraza también.



73. El otoño es oscuro y el invierno también.  
74. El otoño es \*oscuros y el invierno también.  
75. El otoño es \*oscura y el invierno también.
76. El otoño es húmedo y el verano también.  
77. El otoño es \*húmedos y el verano también.  
78. El otoño es \*húmeda y el verano también.
79. La mesa es pesada y la silla también.  
80. La mesa es \*pesadas y la silla también.  
81. La mesa es \*pesado y la silla también.
82. La mesa es inmensa y la cama también.  
83. La mesa es \*inmensas y la cama también.  
84. La mesa es \*inmenso y la cama también.
85. El baño es amplio y el pasillo también.  
86. El baño es \*amplios y el pasillo también.  
87. El baño es \*amplia y el pasillo también.
88. El baño es rosado y el dormitorio también.  
89. El baño es \*rosados y el dormitorio también.  
90. El baño es \*rosada y el dormitorio también.
91. La montaña es grandiosa y la colina también.  
92. La montaña es \*grandiosas y la colina también.  
93. La montaña es \*grandioso y la colina también.
94. La montaña es rocosa y la sierra también.  
95. La montaña es \*rocosas y la sierra también.  
96. La montaña es \*rocoso y la sierra también.
97. El abrigo es clásico y el chaleco también.  
98. El abrigo es \*clásicos y el chaleco también.  
99. El abrigo es \*clásica y el chaleco también.
100. El abrigo es caluroso y el gorro también.  
101. El abrigo es \*calurosos y el gorro también.  
102. El abrigo es \*calurosa y el gorro también.
103. La biblioteca es gratuita y la sauna también.  
104. La biblioteca es \*gratuitas y la sauna también.  
105. La biblioteca es \*gratuito y la sauna también.
106. La biblioteca es formativa y la escuela también.  
107. La biblioteca es \*formativas y la escuela también.  
108. La biblioteca es \*formativo y la escuela también.

- 109. El terremoto es peligroso y el tornado también.
- 110. El terremoto es \*peligrosos y el tornado también.
- 111. El terremoto es \*peligrosa y el tornado también.
  
- 112. El terremoto es catastrófico y el maremoto también.
- 113. El terremoto es \*catastróficos y el maremoto también.
- 114. El terremoto es \*catastrófica y el maremoto también.
  
- 115. La fresa es ácida y la piña también.
- 116. La fresa es \*ácidas y la piña también.
- 117. La fresa es \*ácido y la piña también.
  
- 118. La fresa es digestiva y la zanahoria también.
- 119. La fresa es \*digestivas y la zanahoria también.
- 120. La fresa es \*digestivo y la zanahoria también.
  
- 121. El libro es didáctico y el periódico también.
- 122. El libro es \*didácticos y el periódico también.
- 123. El libro es \*didáctica y el periódico también.
  
- 124. El libro es anónimo y el artículo también.
- 125. El libro es \*anónimos y el artículo también.
- 126. El libro es \*anónima y el artículo también.
  
- 127. La guitarra es melodiosa y la flauta también.
- 128. La guitarra es \*melodiosas y la flauta también.
- 129. La guitarra es \*melodioso y la flauta también.
  
- 130. La guitarra es bonita y la armónica también.
- 131. La guitarra es \*bonitas y la armónica también.
- 132. La guitarra es \*bonito y la armónica también.
  
- 133. El laboratorio es conocido y el departamento también.
- 134. El laboratorio es \*conocidos y el departamento también.
- 135. El laboratorio es \*conocida y el departamento también.
  
- 136. El laboratorio es privado y el archivo también.
- 137. El laboratorio es \*privados y el archivo también.
- 138. El laboratorio es \*privada y el archivo también.
  
- 139. La película es romántica y la leyenda también.
- 140. La película es \*románticas y la leyenda también.
- 141. La película es \*romántico y la leyenda también.
  
- 142. La película es patética y la crítica también.
- 143. La película es \*patéticas y la crítica también.
- 144. La película es \*patético y la crítica también.

145. El lago es oscuro y el pozo también.
146. El lago es \*oscuros y el pozo también.
147. El lago es \*oscura y el pozo también.
  
148. El lago es hondo y el pantano también.
149. El lago es \*hondos y el pantano también.
150. El lago es \*honda y el pantano también.
  
151. La cortina es fina y la moqueta también.
152. La cortina es \*finas y la moqueta también.
153. La cortina es \*fino y la moqueta también.
  
154. La cortina es decorativa y la alfombra también.
155. La cortina es \*decorativas y la alfombra también.
156. La cortina es \*decorativo y la alfombra también.
  
157. El espejo es delicado y el florero también.
158. El espejo es \*delicados y el florero también.
159. El espejo es \*delicada y el florero también.
  
160. El espejo es precioso y el mosaico también.
161. El espejo es \*preciosos y el mosaico también.
162. El espejo es \*preciosa y el mosaico también.
  
163. La cafetera es metálica y la tetera también.
164. La cafetera es \*metálicas y la tetera también.
165. La cafetera es \*metálico y la tetera también.
  
166. La cafetera es vieja y la tostadora también.
167. La cafetera es \*viejas y la tostadora también.
168. La cafetera es \*viejo y la tostadora también.
  
169. El disco es alternativo y el concierto también.
170. El disco es \*alternativos y el concierto también.
171. El disco es \*alternativa y el concierto también.
  
172. El disco es conocido y el grupo también.
173. El disco es \*conocidos y el grupo también.
174. El disco es \*conocida y el grupo también.
  
175. La maleta es pesada y la cartera también.
176. La maleta es \*pesadas y la cartera también.
177. La maleta es \*pesado y la cartera también.
  
178. La maleta es espaciosa y la caja también.
179. La maleta es \*espaciosas y la caja también.
180. La maleta es \*espacioso y la caja también.

181. El diccionario es pedagógico y el tesoro también.
182. El diccionario es \*pedagógicos y el tesoro también.
183. El diccionario es \*pedagógica y el tesoro también.
  
184. El diccionario es didáctico y el glosario también.
185. El diccionario es \*didácticos y el glosario también.
186. El diccionario es \*didáctica y el glosario también.
  
187. La ventana es amarilla y la escalera también.
188. La ventana es \*amarillas y la escalera también.
189. La ventana es \*amarillo y la escalera también.
  
190. La ventana es metálica y la puerta también.
191. La ventana es \*metálicas y la puerta también.
192. La ventana es \*metálico y la puerta también.
  
193. El gramófono es viejo y el cronómetro también.
194. El gramófono es \*viejos y el cronómetro también.
195. El gramófono es \*vieja y el cronómetro también.
  
196. El gramófono es automático y el estéreo también.
197. El gramófono es \*automáticos y el estéreo también.
198. El gramófono es \*automática y el estéreo también.
  
199. La corona es dorada y la cadena también.
200. La corona es \*doradas y la cadena también.
201. La corona es \*dorado y la cadena también.
  
202. La corona es auténtica y la sortija también.
203. La corona es \*auténticas y la sortija también.
204. La corona es \*auténtico y la sortija también.
  
205. El cuadro es auténtico y el grabado también.
206. El cuadro es \*auténticos y el grabado también.
207. El cuadro es \*auténtica y el grabado también.
  
208. El cuadro es expresivo y el retrato también.
209. El cuadro es \*expresivos y el retrato también.
210. El cuadro es \*expresiva y el retrato también.
  
211. La academia es prestigiosa y la galería también.
212. La academia es \*prestigiosas y la galería también.
213. La academia es \*prestigioso y la galería también.
  
214. La academia es pública y la guardería también.
215. La academia es \*públicas y la guardería también.
216. La academia es \*público y la guardería también.

217. El narciso es rosado y el gladiolo también.
218. El narciso es \*rosados y el gladiolo también.
219. El narciso es \*rosada y el gladiolo también.
  
220. El narciso es decorativo y el lirio también.
221. El narciso es \*decorativos y el lirio también.
222. El narciso es \*decorativa y el lirio también.
  
223. La pastelería es famosa y la bombonería también.
224. La pastelería es \*famosas y la bombonería también.
225. La pastelería es \*famoso y la bombonería también.
  
226. La pastelería es minúscula y la panadería también.
227. La pastelería es \*minúsculas y la panadería también.
228. La pastelería es \*minúsculo y la panadería también.
  
229. El cuento es creativo y el relato también.
230. El cuento es \*creativos y el relato también.
231. El cuento es \*creativa y el relato también.
  
232. El cuento es anónimo y el manuscrito también.
233. El cuento es \*anónimos y el manuscrito también.
234. El cuento es \*anónima y el manuscrito también.
  
235. La conferencia es privada y la fiesta también.
236. La conferencia es \*privadas y la fiesta también.
237. La conferencia es \*privado y la fiesta también.
  
238. La conferencia es corta y la entrevista también.
239. La conferencia es \*cortas y la entrevista también.
240. La conferencia es \*corto y la entrevista también.
  
241. El tango es erótico y el flamenco también.
242. El tango es \*eróticos y el flamenco también.
243. El tango es \*erótica y el flamenco también.
  
244. El tango es rápido y el mambo también.
245. El tango es \*rápidos y el mambo también.
246. El tango es \*rápida y el mambo también.
  
247. La iglesia es misteriosa y la cripta también.
248. La iglesia es \*misteriosas y la cripta también.
249. La iglesia es \*misterioso y la cripta también.
  
250. La iglesia es emblemática y la abadía también.
251. La iglesia es \*emblemática y la abadía también.
252. La iglesia es \*emblemática y la abadía también.

253. El trópico es caluroso y el desierto también.  
254. El trópico es \*calurosos y el desierto también.  
255. El trópico es \*calurosa y el desierto también.
256. El trópico es florido y el prado también.  
257. El trópico es \*floridos y el prado también.  
258. El trópico es \*florida y el prado también.
259. La espada es afilada y la flecha también.  
260. La espada es \*afiladas y la flecha también.  
261. La espada es \*afilado y la flecha también.
262. La espada es dorada y la lanza también.  
263. La espada es \*doradas y la lanza también.  
264. La espada es \*dorado y la lanza también.
265. El contrato es justo y el pago también.  
266. El contrato es \*justos y el pago también.  
267. El contrato es \*justa y el pago también.
268. El contrato es estricto y el reglamento también.  
269. El contrato es \*estrictos y el reglamento también.  
270. El contrato es \*estricta y el reglamento también.
271. La sentencia es justa y la condena también.  
272. La sentencia es \*justas y la condena también.  
273. La sentencia es \*justo y la condena también.
274. La sentencia es estricta y la pena también.  
275. La sentencia es \*estrictas y la pena también.  
276. La sentencia es \*estricto y la pena también.
277. El motociclismo es entretenido y el judo también.  
278. El motociclismo es \*entretenidos y el judo también.  
279. El motociclismo es \*entretenida y el judo también.
280. El motociclismo es divertido y el automovilismo también.  
281. El motociclismo es \*divertidos y el automovilismo también.  
282. El motociclismo es \*divertida y el automovilismo también.
283. La cámara es automática y la calculadora también.  
284. La cámara es \*automáticas y la calculadora también.  
285. La cámara es \*automático y la calculadora también.
286. La cámara es moderna y la agenda también.  
287. La cámara es \*modernas y la agenda también.  
288. La cámara es \*moderno y la agenda también.

289. El vestido es sobrio y el velo también.  
290. El vestido es \*sobrios y el velo también.  
291. El vestido es \*sobria y el velo también.
292. El vestido es azulado y el manto también.  
293. El vestido es \*azulados y el manto también.  
294. El vestido es \*azulada y el manto también.
295. La samba es erótica y la lambada también.  
296. La samba es \*eróticas y la lambada también.  
297. La samba es \*erótico y la lambada también.
298. La samba es melodiosa y la rumba también.  
299. La samba es \*melodiosas y la rumba también.  
300. La samba es \*melodioso y la rumba también.
301. El empleo es patético y el sueldo también.  
302. El empleo es \*patéticos y el sueldo también.  
303. El empleo es \*patética y el sueldo también.
304. El empleo es intenso y el horario también.  
305. El empleo es \*intensos y el horario también.  
306. El empleo es \*intensa y el horario también.
307. La batalla es violenta y la lucha también.  
308. La batalla es \*violentas y la lucha también.  
309. La batalla es \*violento y la lucha también.
310. La batalla es catastrófica y la guerra también.  
311. La batalla es \*catastróficas y la guerra también.  
312. La batalla es \*catastrófico y la guerra también.
313. El plátano es beneficioso y el coco también.  
314. El plátano es \*beneficiosos y el coco también.  
315. El plátano es \*beneficiosa y el coco también.
316. El plátano es amarillo y el mango también.  
317. El plátano es \*amarillos y el mango también.  
318. El plátano es \*amarilla y el mango también.
319. La huella es humana y la reliquia también.  
320. La huella es \*humanas y la reliquia también.  
321. La huella es \*humano y la reliquia también.
322. La huella es antigua y la calavera también.  
323. La huella es \*antiguas y la calavera también.  
324. La huella es \*antiguo y la calavera también.

325. El submarino es rápido y el hidroplano también.  
 326. El submarino es \*rápidos y el hidroplano también.  
 327. El submarino es \*rápida y el hidroplano también.
328. El submarino es inmenso y el pesquero también.  
 329. El submarino es \*inmensos y el pesquero también.  
 330. El submarino es \*inmensa y el pesquero también.
331. La boda es sencilla y la ceremonia también.  
 332. La boda es \*sencillas y la ceremonia también.  
 333. La boda es \*sencilla y la ceremonia también.
334. La boda es tranquila y la gala también.  
 335. La boda es \*tranquilas y la gala también.  
 336. La boda es \*tranquilo y la gala también.
337. El camino es corto y el atajo también.  
 338. El camino es \*cortos y el atajo también.  
 339. El camino es \*corta y el atajo también.
340. El camino es feo y el pueblo también.  
 341. El camino es \*feos y el pueblo también.  
 342. El camino es \*fea y el pueblo también.
343. La plaza es pública y la avenida también.  
 344. La plaza es \*públicas y la avenida también.  
 345. La plaza es \*público y la avenida también.
346. La plaza es fea y la basílica también.  
 347. La plaza es \*feas y la basílica también.  
 348. La plaza es \*feo y la basílica también.
349. El gobierno es autoritario y el ejército también.  
 350. El gobierno es \*autoritarios y el ejército también.  
 351. El gobierno es \*autoritaria y el ejército también.
352. El gobierno es poderoso y el parlamento también.  
 353. El gobierno es \*poderosos y el parlamento también.  
 354. El gobierno es \*poderosa y el parlamento también.
355. La aristocracia es poderosa y la burguesía también.  
 356. La aristocracia es \*poderosas y la burguesía también.  
 357. La aristocracia es \*poderoso y la burguesía también.
358. La aristocracia es rica y la realeza también.  
 359. La aristocracia es \*ricas y la realeza también.  
 360. La aristocracia es \*rico y la realeza también.



### APPENDIX 3: Stimuli in Experiment 3

1. Francisco olvidó este cuaderno el sábado pasado.
2. Francisco olvidó estos \*cuaderno el sábado pasado.
3. Francisco olvidó esta \*cuaderno el sábado pasado.
  
4. Sandra alquiló esta tienda la semana pasada.
5. Sandra alquiló estas \*tienda la semana pasada.
6. Sandra alquiló este \*tienda la semana pasada.
  
7. Rodrigo utilizó este bolígrafo el sábado pasado.
8. Rodrigo utilizó estos \*bolígrafo el sábado pasado.
9. Rodrigo utilizó esta \*bolígrafo el sábado pasado.
  
10. Sara alquiló esta avioneta la semana pasada.
11. Sara alquiló estas \*avioneta la semana pasada.
12. Sara alquiló este \*avioneta la semana pasada.
  
13. Diego limpió este lavabo el sábado pasado.
14. Diego limpió estos \*lavabo el sábado pasado.
15. Diego limpió esta \*lavabo el sábado pasado.
  
16. Ana arregló esta lámpara la semana pasada.
17. Ana arregló estas \*lámpara la semana pasada.
18. Ana arregló este \*lámpara la semana pasada.
  
19. Mateo limpió este apartamento el sábado pasado.
20. Mateo limpió estos \*apartamento el sábado pasado.
21. Mateo limpió esta \*apartamento el sábado pasado.
  
22. Laura arregló esta bicicleta la semana pasada.
23. Laura arregló estas \*bicicleta la semana pasada.
24. Laura arregló este \*bicicleta la semana pasada.
  
25. Alberto ganó este premio el sábado pasado.
26. Alberto ganó estos \*premio el sábado pasado.
27. Alberto ganó esta \*premio el sábado pasado.
  
28. Fátima visitó esta capilla la semana pasada.
29. Fátima visitó estas \*capilla la semana pasada.
30. Fátima visitó este \*capilla la semana pasada.
  
31. Alejandro heredó este piso el sábado pasado.
32. Alejandro heredó estos \*piso el sábado pasado.
33. Alejandro heredó esta \*piso el sábado pasado.
  
34. Elisa encontró esta pulsera la semana pasada.
35. Elisa encontró estas \*pulsera la semana pasada.
36. Elisa encontró este \*pulsera la semana pasada.

37. Alfonso pintó este cuarto el sábado pasado.
38. Alfonso pintó estos \*cuarto el sábado pasado.
39. Alfonso pintó esta \*cuarto el sábado pasado.
  
40. Amelia ganó esta medalla la semana pasada.
41. Amelia ganó estas \*medalla la semana pasada.
42. Amelia ganó este \*medalla la semana pasada.
  
43. Adolfo encontró este trabajo el sábado pasado.
44. Adolfo encontró estos \*trabajo el sábado pasado.
45. Adolfo encontró esta \*trabajo el sábado pasado.
  
46. Susana pintó esta sala la semana pasada.
47. Susana pintó estas \*sala la semana pasada.
48. Susana pintó este \*sala la semana pasada.
  
49. Alfredo redactó este discurso el sábado pasado.
50. Alfredo redactó estos \*discurso el sábado pasado.
51. Alfredo redactó esta \*discurso el sábado pasado.
  
52. Carolina preparó esta tarta la semana pasada.
53. Carolina preparó estas \*tarta la semana pasada.
54. Carolina preparó este \*tarta la semana pasada.
  
55. Antonio organizó este congreso el sábado pasado.
56. Antonio organizó estos \*congreso el sábado pasado.
57. Antonio organizó esta \*congreso el sábado pasado.
  
58. Macarena planchó esta toalla la semana pasada.
59. Macarena planchó estas \*toalla la semana pasada.
60. Macarena planchó este \*toalla la semana pasada.
  
61. Arturo lavó este trapo el sábado pasado.
62. Arturo lavó estos \*trapo el sábado pasado.
63. Arturo lavó esta \*trapo el sábado pasado.
  
64. Diana lavó esta toalla la semana pasada.
65. Diana lavó estas \*toalla la semana pasada.
66. Diana lavó este \*toalla la semana pasada.
  
67. Sergio terminó este dibujo el sábado pasado.
68. Sergio terminó estos \*dibujo el sábado pasado.
69. Sergio terminó esta \*dibujo el sábado pasado.
  
70. Clara empezó esta botella la semana pasada.
71. Clara empezó estas \*botella la semana pasada.
72. Clara empezó este \*botella la semana pasada.

73. Eugenio quebró este plato el sábado pasado.  
74. Eugenio quebró estos \*plato el sábado pasado.  
75. Eugenio quebró esta \*plato el sábado pasado.
76. Sonia empezó esta caricatura la semana pasada.  
77. Sonia empezó estas \*caricatura la semana pasada.  
78. Sonia empezó este \*caricatura la semana pasada.
79. Roberto firmó este acuerdo el sábado pasado.  
80. Roberto firmó estos \*acuerdo el sábado pasado.  
81. Roberto firmó esta \*acuerdo el sábado pasado.
82. Mónica explicó esta pregunta la semana pasada.  
83. Mónica explicó estas \*pregunta la semana pasada.  
84. Mónica explicó este \*pregunta la semana pasada.
85. Pablo creó este equipo el sábado pasado.  
86. Pablo creó estos \*equipo el sábado pasado.  
87. Pablo creó esta \*equipo el sábado pasado.
88. Adela firmó esta carta la semana pasada.  
89. Adela firmó estas \*carta la semana pasada.  
90. Adela firmó este \*carta la semana pasada.
91. Ricardo redactó este capítulo el sábado pasado.  
92. Ricardo redactó estos \*capítulo el sábado pasado.  
93. Ricardo redactó esta \*capítulo el sábado pasado.
94. Alicia utilizó esta botella la semana pasada.  
95. Alicia utilizó estas \*botella la semana pasada.  
96. Alicia utilizó este \*botella la semana pasada.
97. Hugo explicó este capítulo el sábado pasado.  
98. Hugo explicó estos \*capítulo el sábado pasado.  
99. Hugo explicó esta \*capítulo el sábado pasado.
100. Andrea selló esta carta la semana pasada.  
101. Andrea selló estas \*carta la semana pasada.  
102. Andrea selló este \*carta la semana pasada.
103. Leonardo usó este cuarto el sábado pasado.  
104. Leonardo usó estos \*cuarto el sábado pasado.  
105. Leonardo usó esta \*cuarto el sábado pasado.
106. Ángela rechazó esta propuesta la semana pasada.  
107. Ángela rechazó estas \*propuesta la semana pasada.  
108. Ángela rechazó este \*propuesta la semana pasada.

109. Ignacio rechazó este premio el sábado pasado.
110. Ignacio rechazó estos \*premio el sábado pasado.
111. Ignacio rechazó esta \*premio el sábado pasado.
  
112. Aurora anunció esta propuesta la semana pasada.
113. Aurora anunció estas \*propuesta la semana pasada.
114. Aurora anunció este \*propuesta la semana pasada.
  
115. Mauricio anunció este acuerdo el sábado pasado.
116. Mauricio anunció estos \*acuerdo el sábado pasado.
117. Mauricio anunció esta \*acuerdo el sábado pasado.
  
118. Bárbara probó esta tarta la semana pasada.
119. Bárbara probó estas \*tarta la semana pasada.
120. Bárbara probó este \*tarta la semana pasada.
  
121. Jacobo acabó este cuaderno el sábado pasado.
122. Jacobo acabó estos \*cuaderno el sábado pasado.
123. Jacobo acabó esta \*cuaderno el sábado pasado.
  
124. Berta decoró esta tienda la semana pasada.
125. Berta decoró estas \*tienda la semana pasada.
126. Berta decoró este \*tienda la semana pasada.
  
127. Lorenzo selló este certificado el sábado pasado.
128. Lorenzo selló estos \*certificado el sábado pasado.
129. Lorenzo selló esta \*certificado el sábado pasado.
  
130. Camila editó esta revista la semana pasada.
131. Camila editó estas \*revista la semana pasada.
132. Camila editó este \*revista la semana pasada.
  
133. Armando editó este certificado el sábado pasado.
134. Armando editó estos \*certificado el sábado pasado.
135. Armando editó esta \*certificado el sábado pasado.
  
136. Cecilia encargó esta caricatura la semana pasada.
137. Cecilia encargó estas \*caricatura la semana pasada.
138. Cecilia encargó este \*caricatura la semana pasada.
  
139. Aurelio probó este bizcocho el sábado pasado.
140. Aurelio probó estos \*bizcocho el sábado pasado.
141. Aurelio probó esta \*bizcocho el sábado pasado.
  
142. Celia examinó esta avioneta la semana pasada.
143. Celia examinó estas \*avioneta la semana pasada.
144. Celia examinó este \*avioneta la semana pasada.

145. Augusto encargó este bizcocho el sábado pasado.
146. Augusto encargó estos \*bizcocho el sábado pasado.
147. Augusto encargó esta \*bizcocho el sábado pasado.
  
148. Claudia decoró esta sala la semana pasada.
149. Claudia decoró estas \*sala la semana pasada.
150. Claudia decoró este \*sala la semana pasada.
  
151. Bernardo examinó este dibujo el sábado pasado.
152. Bernardo examinó estos \*dibujo el sábado pasado.
153. Bernardo examinó esta \*dibujo el sábado pasado.
  
154. Cristina fundó esta empresa la semana pasada.
155. Cristina fundó estas \*empresa la semana pasada.
156. Cristina fundó este \*empresa la semana pasada.
  
157. Eduardo aceptó este trabajo el sábado pasado.
158. Eduardo aceptó estos \*trabajo el sábado pasado.
159. Eduardo aceptó esta \*trabajo el sábado pasado.
  
160. Daniela creó esta empresa la semana pasada.
161. Daniela creó estas \*empresa la semana pasada.
162. Daniela creó este \*empresa la semana pasada.
  
163. Emilio organizó este equipo el sábado pasado.
164. Emilio organizó estos \*equipo el sábado pasado.
165. Emilio organizó esta \*equipo el sábado pasado.
  
166. Elena publicó esta noticia la semana pasada.
167. Elena publicó estas \*noticia la semana pasada.
168. Elena publicó este \*noticia la semana pasada.
  
169. Ernesto investigó este suceso el sábado pasado.
170. Ernesto investigó estos \*suceso el sábado pasado.
171. Ernesto investigó esta \*suceso el sábado pasado.
  
172. Elvira publicó esta revista la semana pasada.
173. Elvira publicó estas \*revista la semana pasada.
174. Elvira publicó este \*revista la semana pasada.
  
175. Federico reveló este suceso el sábado pasado.
176. Federico reveló estos \*suceso el sábado pasado.
177. Federico reveló esta \*suceso el sábado pasado.
  
178. Estefanía reveló esta noticia la semana pasada.
179. Estefanía reveló estas \*noticia la semana pasada.
180. Estefanía reveló este \*noticia la semana pasada.

181. Fernando quebró este bolígrafo el sábado pasado.
182. Fernando quebró estos \*bolígrafo el sábado pasado.
183. Fernando quebró esta \*bolígrafo el sábado pasado.
  
184. Natalia aceptó esta medalla la semana pasada.
185. Natalia aceptó estas \*medalla la semana pasada.
186. Natalia aceptó este \*medalla la semana pasada.
  
187. Gregorio inauguró este congreso el sábado pasado.
188. Gregorio inauguró estos \*congreso el sábado pasado.
189. Gregorio inauguró esta \*congreso el sábado pasado.
  
190. Eva investigó esta compañía la semana pasada.
191. Eva investigó estas \*compañía la semana pasada.
192. Eva investigó este \*compañía la semana pasada.
  
193. Guillermo fundó este orfanato el sábado pasado.
194. Guillermo fundó estos \*orfanato el sábado pasado.
195. Guillermo fundó esta \*orfanato el sábado pasado.
  
196. Silvia realizó esta tarea la semana pasada.
197. Silvia realizó estas \*tarea la semana pasada.
198. Silvia realizó este \*tarea la semana pasada.
  
199. Gustavo llenó este depósito el sábado pasado.
200. Gustavo llenó estos \*depósito el sábado pasado.
201. Gustavo llenó esta \*depósito el sábado pasado.
  
202. Julia reparó esta bicicleta la semana pasada.
203. Julia reparó estas \*bicicleta la semana pasada.
204. Julia reparó este \*bicicleta la semana pasada.
  
205. Humberto ordenó este armario el sábado pasado.
206. Humberto ordenó estos \*armario el sábado pasado.
207. Humberto ordenó esta \*armario el sábado pasado.
  
208. Violeta cambió esta pulsera la semana pasada.
209. Violeta cambió estas \*pulsera la semana pasada.
210. Violeta cambió este \*pulsera la semana pasada.
  
211. Rodolfo vació este armario el sábado pasado.
212. Rodolfo vació estos \*armario el sábado pasado.
213. Rodolfo vació esta \*armario el sábado pasado.
  
214. Juana heredó esta compañía la semana pasada.
215. Juana heredó estas \*compañía la semana pasada.
216. Juana heredó este \*compañía la semana pasada.

217. Ramiro reparó este lavabo el sábado pasado.  
218. Ramiro reparó estos \*lavabo el sábado pasado.  
219. Ramiro reparó esta \*lavabo el sábado pasado.
220. Josefina ordenó esta oficina la semana pasada.  
221. Josefina ordenó estas \*oficina la semana pasada.  
222. Josefina ordenó este \*oficina la semana pasada.
223. Darío inauguró este museo el sábado pasado.  
224. Darío inauguró estos \*museo el sábado pasado.  
225. Darío inauguró esta \*museo el sábado pasado.
226. Lara aclaró esta pregunta el sábado pasado.  
227. Lara aclaró estas \*pregunta el sábado pasado.  
228. Lara aclaró este \*pregunta el sábado pasado.
229. Demetrio visitó este museo el sábado pasado.  
230. Demetrio visitó estos \*museo el sábado pasado.  
231. Demetrio visitó esta \*museo el sábado pasado.
232. Leticia mencionó esta oficina la semana pasada.  
233. Leticia mencionó estas \*oficina la semana pasada.  
234. Leticia mencionó este \*oficina la semana pasada.
235. Dionisio mencionó este orfanato el sábado pasado.  
236. Dionisio mencionó estos \*orfanato el sábado pasado.  
237. Dionisio mencionó esta \*orfanato el sábado pasado.
238. Lola diseñó esta capilla la semana pasada.  
239. Lola diseñó estas \*capilla la semana pasada.  
240. Lola diseñó este \*capilla la semana pasada.
241. Gonzalo quemó este trapo el sábado pasado.  
242. Gonzalo quemó estos \*trapo el sábado pasado.  
243. Gonzalo quemó esta \*trapo el sábado pasado.
244. Lidia quemó esta sábana la semana pasada.  
245. Lidia quemó estas \*sábana la semana pasada.  
246. Lidia quemó este \*sábana la semana pasada.
247. Patricio actualizó este catálogo el sábado pasado.  
248. Patricio actualizó estos \*catálogo el sábado pasado.  
249. Patricio actualizó esta \*catálogo el sábado pasado.
250. Lucía diseñó esta estatua la semana pasada.  
251. Lucía diseñó estas \*estatua la semana pasada.  
252. Lucía diseñó este \*estatua la semana pasada.

253. Lázaro acabó este catálogo el sábado pasado.  
254. Lázaro acabó estos \*catálogo el sábado pasado.  
255. Lázaro acabó esta \*catálogo el sábado pasado.
256. Lorena planchó esta sábana la semana pasada.  
257. Lorena planchó estas \*sábana la semana pasada.  
258. Lorena planchó este \*sábana la semana pasada.
259. Jerónimo actualizó este cuestionario el sábado pasado.  
260. Jerónimo actualizó estos \*cuestionario el sábado pasado.  
261. Jerónimo actualizó esta \*cuestionario el sábado pasado.
262. Úrsula compró esta lámpara la semana pasada.  
263. Úrsula compró estas \*lámpara la semana pasada.  
264. Úrsula compró este \*lámpara la semana pasada.
265. Mario usó este cuestionario el sábado pasado.  
266. Mario usó estos \*cuestionario el sábado pasado.  
267. Mario usó esta \*cuestionario el sábado pasado.
268. Marta memorizó esta lista la semana pasada.  
269. Marta memorizó estas \*lista la semana pasada.  
270. Marta memorizó este \*lista la semana pasada.
271. Mariano memorizó este discurso el sábado pasado.  
272. Mariano memorizó estos \*discurso el sábado pasado.  
273. Mariano memorizó esta \*discurso el sábado pasado.
274. Marina preparó esta lista la semana pasada.  
275. Marina preparó estas \*lista la semana pasada.  
276. Marina preparó este \*lista la semana pasada.
277. Rogelio enseñó este apartamento el sábado pasado.  
278. Rogelio enseñó estos \*apartamento el sábado pasado.  
279. Rogelio enseñó esta \*apartamento el sábado pasado.
280. Teresa cargó esta pistola la semana pasada.  
281. Teresa cargó estas \*pistola la semana pasada.  
282. Teresa cargó este \*pistola la semana pasada.
283. Marcelo enseñó este piso el sábado pasado.  
284. Marcelo enseñó estos \*piso el sábado pasado.  
285. Marcelo enseñó esta \*piso el sábado pasado.
286. Noelia cargó esta batería la semana pasada.  
287. Noelia cargó estas \*batería la semana pasada.  
288. Noelia cargó este \*batería la semana pasada.



289. Cesáreo vació este depósito el sábado pasado.  
290. Cesáreo vació estos \*depósito el sábado pasado.  
291. Cesáreo vació esta \*depósito el sábado pasado.
292. Nuria cambió esta batería la semana pasada.  
293. Nuria cambió estas \*batería la semana pasada.  
294. Nuria cambió este \*batería la semana pasada.
295. Gerardo infló este globo el sábado pasado.  
296. Gerardo infló estos \*globo el sábado pasado.  
297. Gerardo infló esta \*globo el sábado pasado.
298. Margarita infló esta pelota la semana pasada.  
299. Margarita infló estas \*pelota la semana pasada.  
300. Margarita infló este \*pelota la semana pasada.
301. Marco confiscó este documento el sábado pasado.  
302. Marco confiscó estos \*documento el sábado pasado.  
303. Marco confiscó esta \*documento el sábado pasado.
304. Virginia restauró esta estatua la semana pasada.  
305. Virginia restauró estas \*estatua la semana pasada.  
306. Virginia restauró este \*estatua la semana pasada.
307. Raimundo restauró este documento el sábado pasado.  
308. Raimundo restauró estos \*documento el sábado pasado.  
309. Raimundo restauró esta \*documento el sábado pasado.
310. Verónica reventó esta pelota la semana pasada.  
311. Verónica reventó estas \*pelota la semana pasada.  
312. Verónica reventó este \*pelota la semana pasada.
313. Paco aclaró este asunto el sábado pasado.  
314. Paco aclaró estos \*asunto el sábado pasado.  
315. Paco aclaró esta \*asunto el sábado pasado.
316. Victoria compró esta carpeta la semana pasada.  
317. Victoria compró estas \*carpeta la semana pasada.  
318. Victoria compró este \*carpeta la semana pasada.
319. Sancho reventó este globo el sábado pasado.  
320. Sancho reventó estos \*globo el sábado pasado.  
321. Sancho reventó esta \*globo el sábado pasado.
322. Enriqueta notificó esta medida la semana pasada.  
323. Enriqueta notificó estas \*medida la semana pasada.  
324. Enriqueta notificó este \*medida la semana pasada.

325. Isidoro notificó este asunto el sábado pasado.  
326. Isidoro notificó estos \*asunto el sábado pasado.  
327. Isidoro notificó esta \*asunto el sábado pasado.
328. Olga confiscó esta pistola la semana pasada.  
329. Olga confiscó estas \*pistola la semana pasada.  
330. Olga confiscó este \*pistola la semana pasada.
331. Anselmo realizó este experimento el sábado pasado.  
332. Anselmo realizó estos \*experimento el sábado pasado.  
333. Anselmo realizó esta \*experimento el sábado pasado.
334. Rita olvidó esta carpeta la semana pasada.  
335. Rita olvidó estas \*carpeta la semana pasada.  
336. Rita olvidó este \*carpeta la semana pasada.
337. Santiago revisó este experimento el sábado pasado.  
338. Santiago revisó estos \*experimento el sábado pasado.  
339. Santiago revisó esta \*experimento el sábado pasado.
340. Frida revisó esta tarea la semana pasada.  
341. Frida revisó estas \*tarea la semana pasada.  
342. Frida revisó este \*tarea la semana pasada.
343. Pedro cantó este himno el sábado pasado.  
344. Pedro cantó estos \*himno el sábado pasado.  
345. Pedro cantó esta \*himno el sábado pasado.
346. Yolanda cantó esta balada la semana pasada.  
347. Yolanda cantó estas \*balada la semana pasada.  
348. Yolanda cantó este \*balada la semana pasada.
349. Gilberto interpretó este himno el sábado pasado.  
350. Gilberto interpretó estos \*himno el sábado pasado.  
351. Gilberto interpretó esta \*himno el sábado pasado.
352. Genoveva interpretó esta balada la semana pasada.  
353. Genoveva interpretó estas \*balada la semana pasada.  
354. Genoveva interpretó este \*balada la semana pasada.
355. Bruno llenó este plato el sábado pasado  
356. Bruno llenó estos \*plato el sábado pasado  
357. Bruno llenó esta \*plato el sábado pasado
358. Sofía terminó esta medida la semana pasada.  
359. Sofía terminó estas \*medida la semana pasada.  
360. Sofía terminó este \*medida la semana pasada.

## **APPENDIX 4: Fillers**

### **7 Word Fillers**

1. Francisco conoció a un piloto muy respetado.
2. Berta recibió a una escritora muy extraña.
3. Rodrigo contempló a un italiano muy moreno.
4. Sara conoció a una francesa muy alta.
5. Diego homenajeó a un piloto muy exitoso.
6. Ana homenajeó a una profesora muy respetada.
7. Rogelio saludó a un italiano muy gordo.
8. Julia abrazó a una profesora muy simpática.
9. Alberto ayudó a un soldado muy problemático.
10. Fátima escuchó a una educadora muy simpática.
11. Alejandro entrevistó a un matemático muy exitoso.
12. Violeta entrevistó a una escritora muy distinguida.
13. Leonardo castigó a un soldado muy perezoso.
14. Natalia castigó a una alumna muy estúpida.
15. Adolfo escuchó a un matemático muy distinguido.
16. Susana cuidó a una educadora muy anciana.
17. Alfredo ayudó a un pasajero muy desorientado.
18. Carolina acompañó a una chiquilla muy pequeña.
19. Antonio acompañó a un pasajero muy anciano.
20. Macarena abrazó a una alumna muy sincera.
21. Sandra saludó a una trabajadora muy maleducada.
22. Mateo cuidó a un enfermo muy problemático.
23. Laura defendió a una chiquilla muy pequeña.

24. Armando defendió a un empleado muy sincero.
25. Elisa despidió a una dependienta muy maleducada.
26. Alfonso despidió a un empleado muy perezoso.
27. Amelia echó a una dependienta muy tonta.
28. Bernardo echó a un universitario muy estúpido.
29. Diana invitó a una francesa muy neurótica.
30. Ernesto invitó a un americano muy alto.
31. Sonia hipnotizó a una trabajadora muy antipática.
32. Fernando hipnotizó a un enfermo muy neurótico.
33. Alicia sonrió a una vendedora muy morena.
34. Hugo sonrió a un viajero muy rubio.
35. Andrea miró a una extranjera muy rubia.
36. Ignacio miró a un viajero muy desorientado.
37. Aurora expulsó a una vendedora muy tonta.
38. Mauricio expulsó a un universitario muy antipático.
39. Bárbara contempló a una extranjera muy extraña.
40. Jacobo recibió a un americano muy gordo.

### **8 Word Fillers**

1. Arturo fotografió a este ministro y Octavio también.
2. Clara gritó a esta secretaria y Natacha también.
3. Sergio insultó a este abogado y Lucio también.
4. Elena gritó a esta limpiadora y Paula también.
5. Eugenio escribió a este ministro y Francisco también.
6. Cecilia aconsejó a esta editora y Valentina también.
7. Roberto escogió a este candidato y Pedro también.

8. Mónica observó a esta limpiadora y Gloria también.
9. Pablo recomendó a este abogado y Laura también.
10. Adela escribió a esta editora y Gabriela también.
11. Ricardo identificó a este testigo y Alejandro también.
12. Ángela recomendó a esta pedagoga y Rosa también.
13. Lorenzo humilló a este becario y Alfredo también.
14. Camila observó a esta maestra y Regina también.
15. Aurelio identificó a este testigo y Edmundo también.
16. Cristina reconoció a esta presentadora y Marisa también.
17. Federico ofendió a este caballero y Pablo también.
18. Eva reconoció a esta artista y Luisa también.
19. Dionisio eligió a este candidato y Mateo también.
20. Silvia insultó a esta maestra y Ágata también.
21. Augusto aconsejó a este caballero y Octavio también.
22. Claudia contradijo a esta pedagoga y Ágata también.
23. Eduardo seleccionó a este ejecutivo y Lucio también.
24. Daniela fotografió a esta artista y Natacha también.
25. Emilio contradijo a este diplomático y Marcelo también.
26. Elvira telefoneó a esta investigadora y Paula también.
27. Guillermo telefoneó a este diplomático y Aurelio también.
28. Estefanía humilló a esta doctora y Valentina también.
29. Gregorio escogió a este ingeniero y Eduardo también.
30. Sofía vio a esta presentadora y Gloria también.
31. Humberto ofendió a este ejecutivo y Ernesto también.
32. Juana llamó a esta doctora y Gabriela también.

33. Ramiro contrató a este médico y Gregorio también.
34. Lara vio a esta bailarina y Rosa también.
35. Demetrio contrató a este ingeniero y Guillermo también.
36. Leticia felicitó a esta bailarina y Regina también.
37. Gonzalo eligió a este médico y Humberto también.
38. Lola felicitó a esta investigadora y Marisa también.
39. Patricio seleccionó a este becario y Gustavo también.
40. Celia llamó a esta secretaria y Luisa también.

### **11 Word Fillers**

1. Gustavo trabajó con un arqueólogo muy aventurero durante todo el año.
2. Teresa vivió con una compañera muy generosa durante toda la primavera.
3. Rodolfo vivió con un sobrino muy sucio durante todo el año.
4. Josefina contactó con una veterinaria muy guapa durante toda la mañana.
5. Darío colaboró con un chico muy presuntuoso durante todo el año.
6. Lidia habló con una señora muy educada durante toda la mañana.
7. Lázaro colaboró con un arquitecto muy culto durante todo el simposio.
8. Lucía habló con una farmacéutica muy trabajadora durante toda la mañana.
9. Jerónimo viajó con un chico muy aventurero durante todo el año.
10. Marta viajó con una amiga muy tímida durante toda la primavera.
11. Paco discutió con un invitado muy soberbio durante todo el simposio.
12. Noelia discutió con una farmacéutica muy grosera durante toda la mañana.
13. Gerardo cooperó con un arqueólogo muy tímido durante todo el año.
14. Margarita cooperó con una enfermera muy respetuosa durante toda la primavera.
15. Marco rivalizó con un vecino muy presuntuoso durante todo el año.

16. Victoria rivalizó con una compañera muy guapa durante toda la primavera.
17. Gilberto contactó con un vecino muy gracioso durante todo el simposio.
18. Enriqueta conversó con una peluquera muy linda durante toda la mañana.
19. Santiago conversó con un invitado muy educado durante todo el simposio.
20. Yolanda trabajó con una enfermera muy atenta durante toda la semana.
21. Lorena entrenó con una niña muy trabajadora durante toda la primavera.
22. Mariano estudió con un filósofo muy excéntrico durante todo el año.
23. Úrsula entrenó con una nadadora muy competitiva durante toda la primavera.
24. Mario charló con un músico muy excéntrico durante todo el simposio.
25. Marina debatió con una señora muy atenta durante toda la mañana.
26. Marcelo debatió con un arquitecto muy respetuoso durante todo el simposio.
27. Nuria compitió con una nadadora muy grosera durante toda la mañana.
28. Cesáreo compitió con un muchacho muy soberbio durante todo el año.
29. Virginia estuvo con una niña muy graciosa durante toda la mañana.
30. Raimundo estudió con un músico muy raro durante todo el año.
31. Verónica bailó con una peluquera muy graciosa durante toda la fiesta.
32. Sancho charló con un sobrino muy cariñoso durante todo el año.
33. Frida bailó con una amiga muy linda durante toda la mañana.
34. Isidoro estuvo con un filósofo muy raro durante todo el simposio.
35. Olga convivió con una tía muy generosa durante toda la primavera.
36. Anselmo convivió con un muchacho muy sucio durante todo el año.
37. Rita dialogó con una tía muy cariñosa durante toda la mañana.
38. Pedro dialogó con un experto muy culto durante todo el simposio.
39. Genoveva consultó con una veterinaria muy antipática durante toda la mañana.
40. Bruno consultó con un experto muy competitivo durante todo el simposio.

## **APPENDIX 5: P600 (400-900ms) Single Electrode Analysis, Experiment 1**

A significant effect of grammaticality was found for CPZ [ $F(2,16) = 9.118$ ;  $p < .002$ ]. Post-hoc tests indicated that grammatical sentences were significantly less negative than number agreement violations [ $F(1,8) = 13.497$ ;  $p < .006$ ] and gender agreement violations [ $F(1,8) = 13.497$ ;  $p < .006$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .586$ ;  $p < .466$ ].

A significant effect of grammaticality was found for CP3 [ $F(1.26, 10.079) = 6.941$ ;  $p < .02$ ] after applying the Greenhouse-Geisser test to correct for a potential violation of the sphericity assumption. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 7.853$ ;  $p < .023$ ] and gender agreement violations [ $F(1,8) = 6.875$ ;  $p < .031$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = 2.119$ ;  $p < .184$ ].

A significant effect of grammaticality was found for P4 [ $F(2,16) = 14.679$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 22.324$ ;  $p < .001$ ] and gender agreement violations [ $F(1,8) = 13.113$ ;  $p < .007$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .53$ ;  $p < .487$ ].

A significant effect of grammaticality was found for O1 [ $F(2,16) = 13.601$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number [ $F(1,8) = 15.622$ ;  $p < .004$ ] and gender agreement violations [ $F(1,8) = 14.772$ ;  $p < .005$ ]. However, the difference between number agreement



violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .001$ ;  $p < .974$ ].

A significant effect of grammaticality was found for PZ [ $F(2,16) = 9.716$ ;  $p < .002$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 14.245$ ;  $p < .005$ ] and gender agreement violations [ $F(1,8) = 8.854$ ;  $p < .018$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .635$ ;  $p < .448$ ].

A significant effect of grammaticality was found for C4 [ $F(2,16) = 4.977$ ;  $p < .021$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number [ $F(1,8) = 5.703$ ;  $p < .044$ ] and gender agreement violations [ $F(1,8) = 7.03$ ;  $p < .029$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .49$ ;  $p < .83$ ].

A significant effect of grammaticality was found for T6 [ $F(2,16) = 24.134$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number [ $F(1,8) = 38.301$ ;  $p < .001$ ] and gender agreement violations [ $F(1,8) = 30.67$ ;  $p < .001$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .310$ ;  $p < .593$ ].

A significant effect of grammaticality was found for O2 [ $F(2,16) = 22.671$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 16.543$ ;  $p < .004$ ] and gender agreement violations [ $F(1,8) = 12.903$ ;  $p < .007$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .112$ ;  $p < .747$ ].

A significant effect of grammaticality was found for CP4 [ $F(2,16) = 11.919$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 21.76$ ;  $p < .002$ ] and gender agreement violations [ $F(1,8) = 11.167$ ;  $p < .01$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .43$ ;  $p < .53$ ].

A significant effect of grammaticality was found for P3 [ $F(2,16) = 9.996$ ;  $p < .002$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 11.864$ ;  $p < .009$ ] and gender agreement violations [ $F(1,8) = 9.886$ ;  $p < .014$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .524$ ;  $p < .490$ ].

A significant effect of grammaticality was found for OZ [ $F(2,16) = 11.47$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 13.265$ ;  $p < .007$ ] and gender agreement violations [ $F(1,8) = 12.429$ ;  $p < .008$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .62$ ;  $p < .81$ ].

A significant effect of grammaticality was found for CZ [ $F(2,16) = 11.47$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 13.265$ ;  $p < .007$ ] and gender agreement violations [ $F(1,8) = 12.429$ ;  $p < .008$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .062$ ;  $p < .810$ ].

A significant effect of grammaticality was found for TP6 [ $F(2,16) = 10.618$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 14.258$ ;  $p < .005$ ] and gender agreement violations [ $F(1,8) = 15.019$ ;  $p < .005$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .10$ ;  $p < .759$ ].

## **APPENDIX 6: P600 (400-900ms) Single Electrode Analysis, Experiment 2**

A significant effect of grammaticality was found for CPZ [ $F(2,16) = 13.801$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 15.815$ ;  $p < .004$ ] and gender agreement violations [ $F(1,8) = 20.835$ ;  $p < .002$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .032$ ;  $p < .863$ ].

A significant effect of grammaticality was found for CP3 [ $F(2,16) = 12.131$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 22.886$ ;  $p < .001$ ] and gender agreement violations [ $F(1,8) = 15.99$ ;  $p < .004$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .001$ ;  $p < .975$ ].

A significant effect of grammaticality was found for P4 [ $F(2,16) = 15.336$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 20.639$ ;  $p < .002$ ] and gender agreement violations [ $F(1,8) = 19.053$ ;  $p < .002$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .067$ ;  $p < .802$ ].

A significant effect of grammaticality was found for O1 [ $F(2,16) = 11.164$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 11.858$ ;  $p < .009$ ] and gender agreement violations [ $F(1,8) = 19.204$ ;  $p < .002$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .012$ ;  $p < .916$ ].

A significant effect of grammaticality was found for PZ [ $F(2,16) = 17.112$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 21.377$ ;  $p < .002$ ] and gender agreement violations [ $F(1,8) = 21.334$ ;  $p < .002$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .001$ ;  $p < .996$ ].

A significant effect of grammaticality was found for C4 [ $F(2,16) = 8.524$ ;  $p < .003$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 12.3$ ;  $p < .008$ ] and gender agreement violations [ $F(1,8) = 10.987$ ;  $p < .011$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .001$ ;  $p < .997$ ].

A significant effect of grammaticality was found for T6 [ $F(2,16) = 23.453$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 45.858$ ;  $p < .001$ ] and gender agreement violations [ $F(1,8) = 24.836$ ;  $p < .001$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .065$ ;  $p < .805$ ].

A significant effect of grammaticality was found for O2 [ $F(2,16) = 10.031$ ;  $p < .002$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 10.461$ ;  $p < .012$ ] and gender agreement violations [ $F(1,8) = 13.902$ ;  $p < .006$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .191$ ;  $p < .673$ ].

A significant effect of grammaticality was found for CP4 [ $F(2,16) = 13.25$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 20.378$ ;  $p < .002$ ] and gender agreement violations [ $F(1,8) = 15.407$ ;  $p < .004$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .067$ ;  $p < .802$ ].

A significant effect of grammaticality was found for P3 [ $F(2,16) = 16.094$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 33.141$ ;  $p < .001$ ] and gender agreement violations [ $F(1,8) = 21.288$ ;  $p < .002$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .044$ ;  $p < .838$ ].

A significant effect of grammaticality was found for OZ [ $F(2,16) = 11.387$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 10.357$ ;  $p < .012$ ] and gender agreement violations [ $F(1,8) = 21.647$ ;  $p < .002$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .62$ ;  $p < .81$ ].

A significant effect of grammaticality was found for CZ [ $F(2,16) = 9.362$ ;  $p < .002$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 11.813$ ;  $p < .009$ ] and gender agreement violations [ $F(1,8) = 15.379$ ;  $p < .004$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .128$ ;  $p < .73$ ].

A significant effect of grammaticality was found for TP6 [ $F(2,16) = 17.859$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 40.132$ ;  $p < .001$ ] and gender agreement violations [ $F(1,8) = 13.687$ ;  $p < .006$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .737$ ;  $p < .416$ ].

### **APPENDIX 7: P600 (400-900ms) Single Electrode Analysis, Experiment 3**

A significant effect of grammaticality was found for CPZ [ $F(2,16) = 15.629$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 15.594$ ;  $p < .004$ ] and gender agreement violations [ $F(1,8) = 25.1$ ;  $p < .001$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .353$ ;  $p < .569$ ].

A significant effect of grammaticality was found for CP3 [ $F(2, 16) = 15.721$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 19.085$ ;  $p < .002$ ] and gender agreement violations [ $F(1,8) = 24.087$ ;  $p < .001$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .352$ ;  $p < .569$ ].

A significant effect of grammaticality was found for P4 [ $F(2,16) = 31.749$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 41.5$ ;  $p < .001$ ] and gender agreement violations [ $F(1,8) = 38.431$ ;  $p < .001$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .009$ ;  $p < .927$ ].

A significant effect of grammaticality was found for O1 [ $F(2,16) = 22.391$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 37.632$ ;  $p < .001$ ] and gender agreement violations [ $F(1,8) = 31.501$ ;  $p < .001$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = 1.428$ ;  $p < .266$ ].



A significant effect of grammaticality was found for PZ [ $F(2,16) = 25.135$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 27.511$ ;  $p < .001$ ] and gender agreement violations [ $F(1,8) = 33.323$ ;  $p < .001$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .30$ ;  $p < .599$ ].

A significant effect of grammaticality was found for C4 [ $F(2,16) = 7.351$ ;  $p < .005$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 8.548$ ;  $p < .019$ ] and gender agreement violations [ $F(1,8) = 8.843$ ;  $p < .018$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = 2.252$ ;  $p < .172$ ].

A significant effect of grammaticality was found for T6 [ $F(2,16) = 17.418$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 27.313$ ;  $p < .001$ ] and gender agreement violations [ $F(1,8) = 22.015$ ;  $p < .002$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = 2.207$ ;  $p < .176$ ].

A significant effect of grammaticality was found for O2 [ $F(2,16) = 14.392$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 16.832$ ;  $p < .003$ ] and gender agreement violations [ $F(1,8) = 19.582$ ;  $p < .002$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = 2.111$ ;  $p < .184$ ].

A significant effect of grammaticality was found for CP4 [ $F(2,16) = 20.934$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 22.609$ ;  $p < .001$ ] and gender agreement violations [ $F(1,8) = 32.013$ ;  $p < .001$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = 1.137$ ;  $p < .317$ ].

A significant effect of grammaticality was found for P3 [ $F(2, 16) = 23.301$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 29.164$ ;  $p < .001$ ] and gender agreement violations [ $F(1,8) = 28.738$ ;  $p < .001$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .001$ ;  $p < .990$ ].

A significant effect of grammaticality was found for P4 [ $F(2,16) = 31.749$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 41.50$ ;  $p < .001$ ] and gender agreement violations [ $F(1,8) = 38.431$ ;  $p < .001$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = .009$ ;  $p < .927$ ].

A significant effect of grammaticality was found for OZ [ $F(2,16) = 18.725$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 25.783$ ;  $p < .001$ ] and gender agreement violations [ $F(1,8) = 24.211$ ;  $p < .001$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = 1.595$ ;  $p < .242$ ].

A significant effect of grammaticality was found for CZ [ $F(2,16) = 9.755$ ;  $p < .002$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 10.797$ ;  $p < .011$ ] and gender agreement violations [ $F(1,8) = 14.019$ ;  $p < .006$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = 1.359$ ;  $p < .277$ ].

A significant effect of grammaticality was found for TP6 [ $F(2,16) = 17.418$ ;  $p < .001$ ]. Post-hoc tests indicated that grammatical sentences were significantly less positive than number agreement violations [ $F(1,8) = 27.313$ ;  $p < .001$ ] and gender agreement violations [ $F(1,8) = 22.015$ ;  $p < .002$ ]. However, the difference between number agreement violations and gender agreement violations failed to reach statistical significance [ $F(1,8) = 2.207$ ;  $p < .176$ ].