Chapter 15 Gender or Genders Agreement?

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15.1 INTRODUCTION

Gender is an important feature that plays a crucial role in agreement. In Spanish, as in other Romance languages, there are three types of gender, that is, semantic, grammatical, and morphological. Semantic gender refers to the biological sex, masculine or feminine, of the word referent in the real world. Thus, only animate nouns with animate referents (especially with human referents) usually have semantic gender. Grammatical gender is a formal characteristic of many words. Because this is an arbitrary characteristic without any conceptual relationship, different words with closely related referents can have different gender forms (e.g., two synonyms can display different grammatical gender), and the same concept across different languages can be represented through masculine or feminine words.

Words of the same grammatical gender tend to share specific phonological properties. Morphological gender refers to the orthographic and phonological representation of grammatical gender. In Spanish, morphological gender can be marked with several suffixes. The "-a" suffix is mostly associated with feminine gender and the "-o" suffix mainly with masculine gender. There are, however, exceptions to this rule, with some feminine gender words ending in "-o" and some masculine gender words ending in "-a", and there are other less frequent suffixes such as "-dad" for feminine, and even some neutral suffixes such as "-e" that apply to both masculine and feminine gender. Finally, many words can change their suffixes under phonological rules or do not display any suffixes at all (opaque gender).

Consider the following Spanish words:

(1) *Abuelo* (grandfather)
(2) *Faro* (lighthouse$_{masc}$)
(3) *Reloj* (clock$_{masc}$)
(4) *Rey* (king)

According to grammatical gender, the four words are masculine, but from a conceptual point of view, only (1) and (4) have semantic gender because only these

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gender forms refer to the sex of the referent in opposition to "grandmother" and "queen," respectively. Furthermore, only (1) and (2) have morphological gender because only these words display at the end of the word the suffix "–o," the canonical suffix for the masculine-singular form in Spanish, while (3) and (4) do notshow any gender marking. It is worth noting that the gender value at any one of these levels is not a reliable indicator of its value at another level.

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Gender features play an important role in determining agreement between words in noun phrases or in the selection of pronominal forms. Gender is marked in nouns, adjectives, articles and pronouns. Establishing agreement relationships between words is a relevant aspect of sentence comprehension and production, especially in Romance languages, which have an overt agreement system among the different elements in sentences. Thus, Spanish relies very heavily on agreement, in contrast to other languages such as English, for which word order is more important than agreement as a grammatical constraint. For instance, in Spanish, all the words in a noun phrase (NP)—determiners, adjectives, and nouns—must agree in number and gender. This way, in the NP *El faro alto* (*The*$_{masc}$ *high*$_{masc}$ *lighthouse*$_{masc}$) the three words are masculine and singular. Similarly, a postverbal adjective has to agree in gender and number with the NP (e.g., *El faro alto es luminoso*; *The*$_{masc}$ *high*$_{masc}$ *lighthouse*$_{masc}$ *is bright*$_{masc}$). The agreement relationships are asymmetrical because adjectives agree with nouns, not vice versa. Consequently, the adjective differs from the noun in that it lacks gender semantic characteristics; in fact, adjectives inherit semantic features from the noun they agree with.

The two different kinds of information carried by the two types of gender (semantic vs. grammatical) can be used to investigate grammatical as opposed to semantic aspects of language processing. Some previous behavioral studies have addressed the use of semantic and grammatical gender information in the interpretation of pronouns in Spanish (Carreiras, Garnham, & Oakhill, 1993; Garnham, Oakhill, Erhlich, & Carreiras, 1995). Sentences were presented containing two antecedents followed by a pronoun referring to one of these. The two antecedents could be of the same gender (e.g., both feminine), thus no gender cue was available, or of two different genders (one masculine and the other feminine), so a gender cue was available for pronoun interpretation. The authors also manipulated whether the two antecedents were of semantic gender or of arbitrary gender. By using a moving-window methodology they found that the sentences containing the pronoun were read faster when the two antecedents were of different gender (gender cue) as compared to when they were of the same gender (no gender cue). This gender cue advantage was similar when the two antecedents were of semantic gender or of grammatical gender. However, questions asked immediately after each sentence only showed a gender cue advantage for semantic gender which led the authors to conclude that semantic gender effects last longer that grammatical gender effects, although the two effects had similar early effects. Nonetheless, another study carried out by Deutsch, Bentin, and Katz (1999) in Hebrew using gender agreement relations between other different constituents has shown that the semantic information carried by semantic gender influenced the agreement processes differently from grammatical gender.

Therefore, comparison between the response to grammatical and semantic gender disagreement using fine-grained methodologies such as ERPs is desirable since

it can help to determine the influence of semantic information (semantic gender information) on grammatical agreement processes (see Osterhout et al., chapter 14, this volume, and van Berkum, chapter 13, this volume, for the advantages of ERPs to capture the time course of cognitive processes). This way, the study of the gender agreement process can shed some light on the more general debate regarding how and when semantics and syntax interact during language comprehension. Therefore, let us summarize what has been found in gender agreement using ERPs.

15.1.1 Event-Related Potentials and Gender Agreement

Using the ERP technique, Osterhout and Mobley (1995) compared gender agreement violations between a reflexive pronoun and its antecedent, and between a personal pronoun and its antecedent in English. The effects of gender violations were not different from the effects of number agreement violations but were different from semantic violations. Semantic violations[1] usually produce a significant enhancement of the N400 component, a negative waveform associated with integration processes (Kutas & Hillyard, 1980; Kutas & Federmeier, 2000). The words that violated agreement rules produced an increase of the P600. The P600, also labeled Syntactic Positive Shift (SPS), is a large positive wave with an onset at about 500 ms and a duration of several hundred milliseconds, which has been reported in response to different kinds of syntactic anomalies (Hagoort, Brown, & Osterhout, 1999). The results of Osterhout and Mobley (1995) point to the syntactic nature of gender agreement more as part of the form than the meaning of language, which is noteworthy, since in English gender is semantically based and usually is not marked through overt morphological indicators. Following government and binding theory, the authors propose that gender features, even when semantically based, might become in a sense independent of the lexical item in order to percolate up to the noun phrase node from the nouns within the sentence.

In a later study, Osterhout, Bersick, and McLaughlin (1997) analyzed the effect of social gender stereotypes in English. Gender agreement violations of reflexive pronouns showed effects on the P600 even when the gender of the subject was not explicit but was inferred from the stereotype (e.g., *The doctor prepared herself…*). This supports the idea that even stereotypical gender could be coded in the representation of some words as an autonomous feature involved in grammatical agreement rules.

In contrast to English, languages such as Dutch, German, Spanish, and Hebrew distinguish between semantic and grammatical gender. Some recent investigations have taken advantage of this to investigate whether the same processing mechanisms underlie agreement for both types of gender. Schmitt, Lamers, and Münte (2002) assessed gender agreement during personal pronoun processing in German. They reported N400 and P600 effects in response to the agreement violation between a pronoun and its animate antecedent (semantic gender). In addition, they used diminutive nouns as antecedents to try to separate semantic from syntactic aspects in agreement processing. In German, diminutive nouns have neuter gender and agree with neuter pronouns but have masculine/feminine determiners, thus, a mismatch of genders is produced in syntactically well-formed sentences. The authors consider this mismatch a semantic violation in opposition to the purely syntactic agreement

violation. They found a P600 effect in response to agreement violations between a gender-marked pronoun and a diminutive neuter noun, indicating that similar syntactic reanalysis processes are engaged during the comprehension of these sentences and the sentences with nondiminutive antecedents. Double violations (a feminine pronoun that disagreed with a diminutive neuter noun with male referent) produced greater amplitudes than single violations (a masculine pronoun that disagreed with a diminutive neuter noun with male referent), pointing to the additive effects triggered by semantic and syntactic factors.

It is noteworthy that the previously described ERP effects were found with violations of semantic gender agreement in pronouns. Hagoort and Brown (1999) manipulated in Dutch the agreement between an article and a noun-within-NP in order to ascertain whether grammatical gender agreement was a semantic or a syntactically based process. Results showed a P600 component effect when violation occurred in the middle of the sentence and an N400–P600 complex at the end of the sentence. Hagoort and Brown concluded that information of grammatical gender agreement processing is not a content-driven process but a syntactic-form-driven process. The N400 effect recorded at the end of the sentence would reflect global sentence integration factors.

In order to study the possible interactions between syntactic and semantic information during agreement processes in German, Gunter, Friederici, and Schriefers (2000) manipulated the cloze probability of a target word and its grammatical gender agreement in the same experimental design. Gender disagreement produced the P600 effect preceded by a left anterior negativity (LAN) effect, while semantic manipulation (cloze probability) produced the classic N400 effect. The LAN effect has been also found with a disparate set of syntactic violations and generally linked to early aspects of syntactic analysis (Friederici, 1995). LAN and N400 share their polarity and sometimes their latency but, while the N400 shows a centro-parietal distribution, the LAN effect is localized in anterior zones and usually lateralized to the left side. In Gunter et als.' (2000) experiment, the N400 effect was not influenced by the syntactic manipulation, and the LAN effect was not influenced by the semantic manipulation. However, there was an interaction between both manipulations in the P600 due to the increase of amplitude of this component for words only with a high cloze probability that violated gender agreement. The authors conclude that syntactic and semantic information are processed autonomously in a first stage, but both types of information interact in a second stage. Moreover, the presence of the LAN effect in this study is interesting as this effect was not present in the gender violations of the experiments described below. A study in Spanish (Demestre, Meltzer, García-Albea, & Vigil, 1999) reported results that could fit in with the LAN-P600 pattern in response to semantic gender agreement violations, although differences in the design (i.e., auditory presentation) and data analysis make comparison with the German study far from straightforward.

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Wicha Moreno, and Kutas (2003) also studied the influence of semantic expectations in grammatical gender agreement in Spanish. They presented a picture in the middle of a sentence, substituting for a word that was semantically predictable or not by the context. They reported a negativity between 500 and 700 ms in response to the nonagreement of the gender associated with the picture

and the gender of the preceding article, and this effect was independent from that of semantic expectations. The authors considered this effect to be the result of gender disagreement, although with characteristics different from that of classical syntactic components as the picture was a stimulus of a different nature. The lack of the classical syntactic components has been found also when gender disagreement is produced in Spanish noun–adjective word pairs presented without a sentence context. In this case, only the N400 effect was reported (Barber & Carreiras, 2003).

Finally, in a study closer to the present experiment, Deutsch and Bentin (2001) analyzed the role of semantic and syntactic information during agreement processing by comparing grammatical and semantic gender processing in Hebrew. Participants read sentences in which the sentential subject was an animate or an inanimate noun, and this noun could be morphologically overtly marked or unmarked. In these sentences, the subject–predicate gender agreement was manipulated (e.g., *the woman saw that the boy/diamond*$_{masc}$ *had fallen*$_{masc/femn}$ *into the pond*). An N400 effect was found after gender agreement violation only for the animate condition (semantic gender) and this effect did not interact with markedness. The N400 effect in the animate condition could show the mismatch of the conceptual information carried by semantic gender. In addition, the violation of either semantic or grammatical gender agreement resulted in a P600 effect, but this effect interacted with the markedness as it was only significant for masculine-plural-marked predicates, that is, only marked forms elicited the P600 effect. In contrast with the Gunter et al. (2000) study, the authors claim that the lack of interaction of the P600 with animacy indicates that the process reflected by this component is not sensitive to semantic information. They relate this component to initial on-line syntactic processing and therefore consider that it is not exclusively associated with the reanalysis processes. In addition, a very early negative effect was reported in response to all the disagreement conditions, but this effect did not fit either in latency or in distribution with the LAN effect previously linked with agreement violations.

PE: The authors in various chapters have used different abbreviations for masculine and feminine, such as masc/femn, mas/fem, m/f, etc.

In summary (see Table 15.1), all the ERP studies showed a P600 effect in response to gender agreement violations with both types of gender (Osterhout & Mobley, 1995; Osterhout et al., 1997; Schmitt et al., 2002; Hagoort & Brown, 1999; Gunter et al., 2000; Demestre et al., 1999; Deutsch & Bentin, 2001). As an exception, the P600 effect was not found with morphologically unmarked words in Hebrew (Deutsch & Bentin). In a Spanish (Demestre et al.) and a German (Gunter et al.) experiment, the P600 effect was preceded by a LAN effect. In addition to these syntactic related indexes, an N400 effect as response to semantic gender violation was reported in a German study (Schmitt et al.) and in the Hebrew study (Deutsch & Bentin, 2001). On the other hand, the N400 effect was not found in other studies that analyzed the semantic gender violation in English (Osterhout & Mobley; Osterhout et al.) and in Spanish (Demestre et al.).

15.1.2 The Present Experiment

The goal of the present study was to further investigate the agreement processes in Spanish involving grammatical and semantic gender. Previous studies in several

Table 15.1. **ERP Effects Obtained in Gender Agreement Violations**

	Target Word	Language	Gender	P600	N400	LAN
Gunter et al., 2000	noun	German	grammatical	*	—	*
Hagoort & Brown, 1999	noun	Dutch	grammatical	*	—	—
Deutch & Bentin, 2001	adjective	Hebrew	grammatical	*	—	—
			semantic	*	*	—
Smicht et al., 2002	personal pronoun	German	semantic	*	*	—
Osterhout & Mobley, 1995	personal pronoun	English	semantic	*	—	—
Osterhout et al., 1997	reflexive pronoun	English	semantic	*	—	—
Demestre et al., 1999	adjective	Spanish	semantic	*	—	*

languages have shown a mixed picture of semantic and grammatical gender agreement effects (see Table 15.1). Thus, in the present experiment, both types of gender were examined under the same circumstances, with transparent gender, in a very simple agreement relationship in Spanish, a language in which agreement processes are crucial for syntactic analysis. The effects of semantic or grammatical gender agreement were studied in sentences in which agreement rules between the NP and a post-verbal adjective were violated. We used animate nouns in the semantic gender condition[2] while all the nouns were unanimate in the grammatical gender condition. We studied the ERPs associated with agreement in the context of reading sentences presented word by word. According to previous results (Demestre et al., 1999; Gunter et al., 2000), LAN and P600 effects were expected in response to agreement violations with both types of gender. However, possible differences in the N400 component in response to semantic gender disagreement or modulations of the syntactic ERP effects by the type of gender could also be predicted (see Deutsch & Bentin, 2001; Schmitt et al., 2002), which would indicate the influence of semantic information in the agreement processes.

15.1.3 Method

15.1.3.1 Participants

A total of 24 undergraduate students, 14 females and 10 males, participated in the experiment in exchange for course credit. All of them were native Spanish speakers with no history of neurological or psychiatric impairment and with normal or corrected-to-normal vision. Ages ranged from 19 to 26 years (mean = 20.8 years). All participants were right-handed as assessed with an abridged Spanish version of the Edinburgh Handedness Inventory (Oldfield, 1971): LQ > + 50. Five of the participants had left-handed relatives. Data of six additional participants were rejected before the analysis because of too many artifacts in the EEG record.

15.1.3.2 Stimuli

For the study, 160 experimental sentences and 160 filler sentences were generated. Experimental sentences were formed with a noun phrase that had to agree in gender with a predicate adjective (agreement in gender between nouns and adjectives is mandatory in Spanish). This adjective was taken as the target word and its gender was manipulated to produce agreement or disagreement with the noun phrase. Between two and four filler words were included after the adjective in order to avoid wrap-up effects on the target word. The noun phrase in half of the experimental sentences was formed by an inanimate noun with only grammatical gender, so in this case gender was always a strictly morphosyntactic feature without semantic significance. The other half of the experimental sentences was formed with an animate noun with grammatical and semantic gender indicating the biological sex of the referent. Half of these two lists of sentences (with grammatical or semantic gender) included an agreement violation in the adjective gender, and the other half consisted of well-formed sentences. In short, the adjectives were manipulated to create four different conditions:

a) Agreement with grammatical gender.
   El faro es luminoso *y alto*.
   The$_{masc}$ *lighthouse*$_{masc}$ *is* bright$_{masc}$ *and high*.
b) Disagreement with grammatical gender.
   El faro es luminosa *y alto*.
   The$_{masc}$ *lighthouse*$_{masc}$ *is* bright$_{fem}$ *and high*.
c) Agreement with semantic gender.
   El abuelo estaba delgado *y débil*.
   The$_{masc}$ *grandfather was* slim$_{masc}$ *and weak*.
d) Disagreement with semantic gender.
   El abuelo estaba delgada *y débil*.
   The$_{masc}$ *grandfather was* slim$_{fem}$ *and weak*.

Nouns and adjectives in all experimental sentences marked the morphological gender with the canonical suffixes, "-a" for feminine and "-o" for masculine. Half the nouns were feminine and half were masculine. Assignment of sentences to conditions in each list was counterbalanced across participants. Thus, each sentence occurred twice across subjects, once in each agreement or disagreement condition so that each subject only saw one form of each sentence during the experiment.

In addition, a list of 160 filler trials was introduced. Some fillers included nouns and adjectives with opaque gender (e.g., the word *reloj* [clock] lacks any explicit morphological mark) or irregular words (e.g., *mano* [hand] ends with the letter "-o" but is feminine). This type of filler was included to prevent participants from using a superficial strategy for solving the task, such as attending just to the suffixes. Half of these filler sentences had a gender agreement violation at the beginning of the sentence, between the determiner and the noun, and half had no gender agreement violation. This way, participants could not focus attention only on the position of the target adjective. In total, each subject received 320 sentences, half of which agreed and the other half disagreed.

15.1.4 Procedure

Participants were seated comfortably in a darkened sound-attenuated chamber. All stimuli were presented on a high-resolution computer that was positioned at eye level 80–90 cm in front of the participant. The words were displayed in black lowercase letters against a gray background.

Participants performed a syntactic judgment task, that is, they said whether the sentence was well-formed or not. A response button was positioned beneath each thumb. For half of the participants the right button was used to signal the "yes" response, and the left button was assigned the "no" response. For the remaining subjects the order was reversed. Thus, the assignment of buttons to hands was counterbalanced across participants.

The sequence of events in each trial is described as follows: First, a fixation point ("+") appeared in the center of the screen and remained there for 300 ms. This fixation point was followed by a blank screen interval of 300 ms, then the sentence was displayed word by word. Each word appeared for 300 ms and was followed by a 300-ms blank interval (SOA = 600 ms). Participants were instructed to respond after the last word of the sentence. At that moment, a question mark was presented and remained there up to a maximum of 2000 ms or until the participant's response. The intertrial interval varied randomly between 2000 and 2500 ms. All sentences were presented in a different pseudorandom order for each participant in two different blocks with a break of 10 min between blocks in which the subject could rest and the impedances were checked.

A total of 10 warm-up sentences were provided at the beginning of the session and were repeated if necessary. Participants were also asked to avoid eye-movements and blinks during the interval when the fixation asterisk was not present, and they were directed to favor accuracy over speed in their responses. Each session lasted approximately $1\int$ hr.

15.1.5 EEG Recording

Scalp voltages were collected from Ag/AgCl electrodes using a 128-channel Geodesic Sensor Net. Figure 15.1 shows the schematic distribution of the recording sites. The vertex electrode was used as reference, and the recording was re-referred offline to linked mastoids. Eye movements and blinks were monitored with supra- and infra-orbital electrodes and with electrodes in the external canthi. Interelectrode impedances were kept below 30 KΩ (amplifiers input impedance <100 MΩ). EEG was filtered with an analogue bandpass filter of 0.01–100 Hz (50 Hz notch filter) and a digital 35 Hz low-pass filter was applied before analysis. The signals were sampled continuously throughout the experiment with a sampling rate of 250 Hz.

15.1.6 Analysis

Epochs of the EEG corresponding to 1200 ms after word onset presentation were averaged and analyzed. Baseline correction was performed using the average EEG activity in the 100 ms preceding the onset of the target word as a reference signal value. Following baseline correction, epochs with simultaneous artifacts in at least

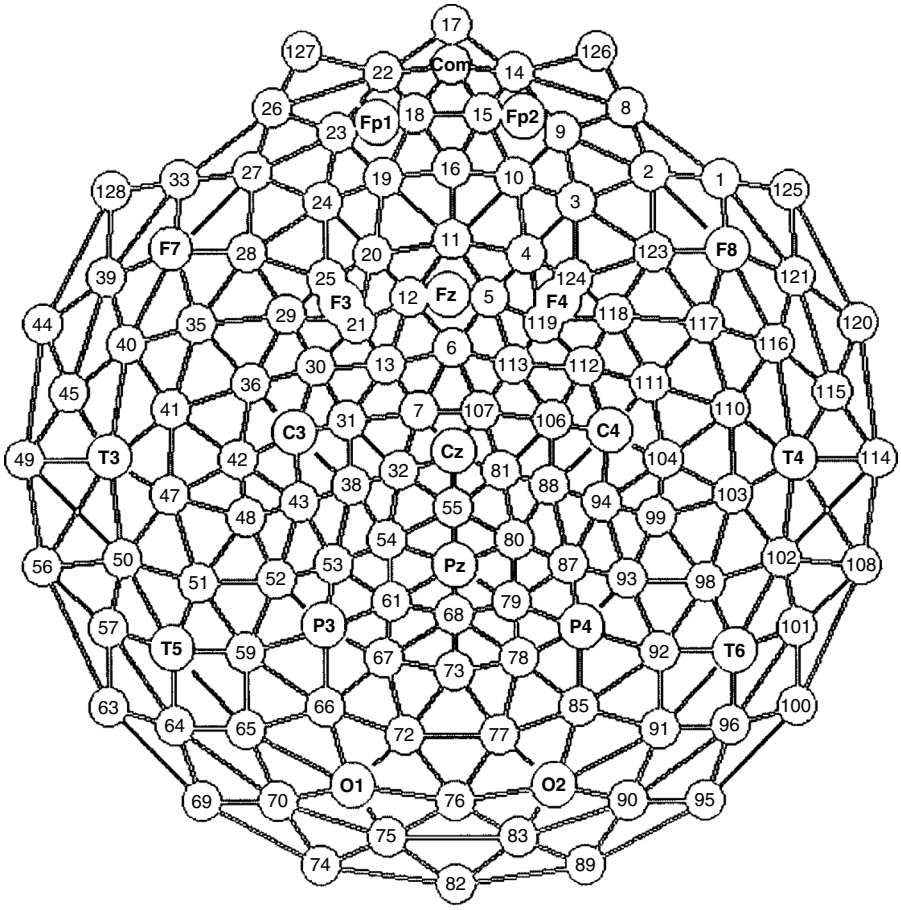

Figure 15.1. Schematic flat representation of the 129 electrode positions from which EEG activity was recorded (front of head is at top). Channel nomenclature is by number. Approximate international 10–20 system localizations are marked.

10 channels were rejected. This operation resulted in the exclusion of approximately 15% of the trials, which was evenly distributed among the different experimental conditions. Furthermore, electrodes with a high level of rejected trials (>10%) were substituted by the average value of the group of nearest electrodes.

Averaging was conducted off-line using only samples recorded in trials in which correct responses had been made in a grammatical judgment task. Separate ERPs were formed for each of the experimental conditions, each of the subjects, and each of the electrode sites.

Nine regions of interest were computed out of the 129 electrodes, each containing the mean of a group of electrodes. The regions were (see electrode numbers in Figure 15.1): midline-anterior (5, 6, 11, and 12), midline-central (7, 55, 107, and 129), midline-central-posterior (62, 68, and 73), left-anterior (13, 20, 21, 25, 28, 29, 30, 34, 35, 36, and 40), left-central (31, 32, 37, 38, 41, 42, 43, 46, 47, 48, and 50), left-posterior

(51, 52, 53, 54, 58, 59, 60, 61, 66, 67, and 72), right-anterior (4, 111, 112, 113, 116, 117, 118, 119, 122, 123, and 124), right-central (81, 88, 94, 99, 102, 103, 104, 105, 106, 109, and 110), right-posterior (77, 78, 79, 80, 85, 86, 87, 92, 93, 97, and 98).

The analyses were carried out in different temporal windows on the basis of calculations of mean amplitude values. Different repeated measures ANOVAs for each type of measures were performed, including the agreement relation (agreement or disagreement) and the type of gender (grammatical or semantic) as within factors. In addition, electrode regions (anterior, central, and posterior) were entered as another within-subject factor. Separate analyses were carried out for the midline regions and the lateral regions. Analysis of the lateral regions included the hemisphere factor with two levels (left/right). A significance level of .05 was adopted for all the statistical tests. Where appropriate, critical values were adjusted using the Geisser–Greenhouse (1959) correction for violation of the assumption of sphericity. Effects related to the electrode regions factor or hemisphere factor will be only reported when they interact with the experimental manipulations. In cases of interaction of any experimental factor with the *electrode region* or *hemisphere*, data were normalized following the vectorial scaled procedure recommended by McCarthy and Wood (1985).

15.2 RESULTS

The ERP grand averages, time-locked to the onset of the target adjectives, are represented in Figures 15.2 and 15.3 over nine recording sites. Figure 15.2 shows the agreement and the disagreement conditions in the sentences with a noun phrase with only grammatical gender. Grand averages of the agreement and disagreement conditions of sentences with semantic gender in the noun phrase are plotted in Figure 15.3. Visual inspection of both figures reveals clear differences in the responses to the disagreement conditions with respect to the agreement conditions, these differences are observed within the 350 to 450 ms window and in the 500 to 700 ms window as well. Between 350 and 450 ms, disagreement waves showed more negative values than those in the agreement condition. These effects are present at anterior electrodes and especially on the left side of the scalp, fitting with the previously described LAN effect. In both figures, the negative effect is followed by a typical P600 effect, showing larger amplitudes for the disagreement conditions than for the agreement ones. These positive differences have a posterior distribution over the midline, slightly lateralized to the right side at the end of the temporal window.

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Statistical analysis supported these observations. The ANOVA with the average values of the 350–450 ms time epoch, including the factor *gender agreement* (agreement and disagreement), the factor *type of gender* (semantic and grammatical), and the factor *electrode regions* (anterior, central, and posterior), indicated a *gender agreement* and *electrode regions* interaction in the midline analysis ($F_{2,22}$ = 3.85; $p < .05$; $\varepsilon = .78$), effect that was maintained after the data normalization ($F_{2,22} = 3.97$; $p < .05$). The lateral regions analysis failed to show any significant effect. Even though the interaction of gender agreement with the factor *electrode* in the lateral analysis was not significant, additional ANOVAs for each electrode area were conducted separately. A *gender agreement* effect was found only in the

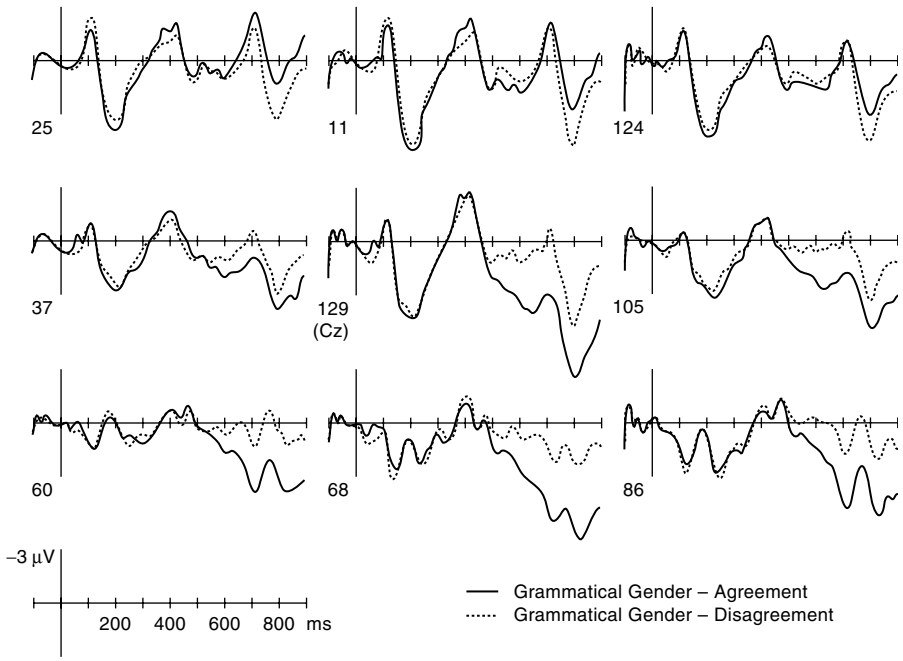

Figure 15.2. Sentences with only grammatical gender in the agreement condition versus the disagreement condition. In this and the following figures, ERPs to the target words (i.e., adjectives) are shown in the three midline, three left, and three right hemisphere electrodes. Onset presentation is at 0 ms and negative amplitude is plotted upward.

anterior area of the midline ($F_{1,23} = 4.64$; $p < .05$), in the left anterior area ($F_{1,23} = 9.73$; $p < .01$), and the left central ($F_{1,23} = 4.36$; $p < .05$) area. No effects of *type of gender* or interactions with this factor were found in any of these analyses.

The ANOVAs for the time epoch from 500 to 700 ms with the same factors as the previous window, *gender agreement*, *type of gender*, and *electrode regions*, revealed a significant main effect of *gender agreement* in the midline analysis ($F_{1,23} = 10.13$; $p < .01$), as well as an interaction between the *gender agreement* and the *electrode regions* factors in the lateral regions analysis ($F_{2,22} = 16.30$; $p < .001$), interaction that was maintained after data normalization ($F_{2,22} = 18.59$; $p < .001$). Likewise, there was an interaction between the *type of gender* and the *electrode regions* factors both in the midline analysis ($F_{2,22} = 7.22$; $p < .01$; $\varepsilon = .61$) and the lateral regions analysis ($F_{2,22} = 4.01$; $p < .05$), and this effect was maintained after data normalization in the midline ($F_{2,22} = 6.53$; $p < .05$) and was marginally significant in the lateral sites ($F_{2,22} = 2.8$; $p = .09$). However, there was no interaction between the factors *gender agreement* and *type of gender*. The different distribution of the two effects was manifested in the ANOVAs realized for each area separately ($p < .05$); the *gender agreement* effect was present in central and posterior areas both in the midline and the lateral sites, while the *type of gender* effect was present in anterior and central areas of the midline sites as well as in the anterior and central sites of the left side. The type of gender effect will be described in more detail below.

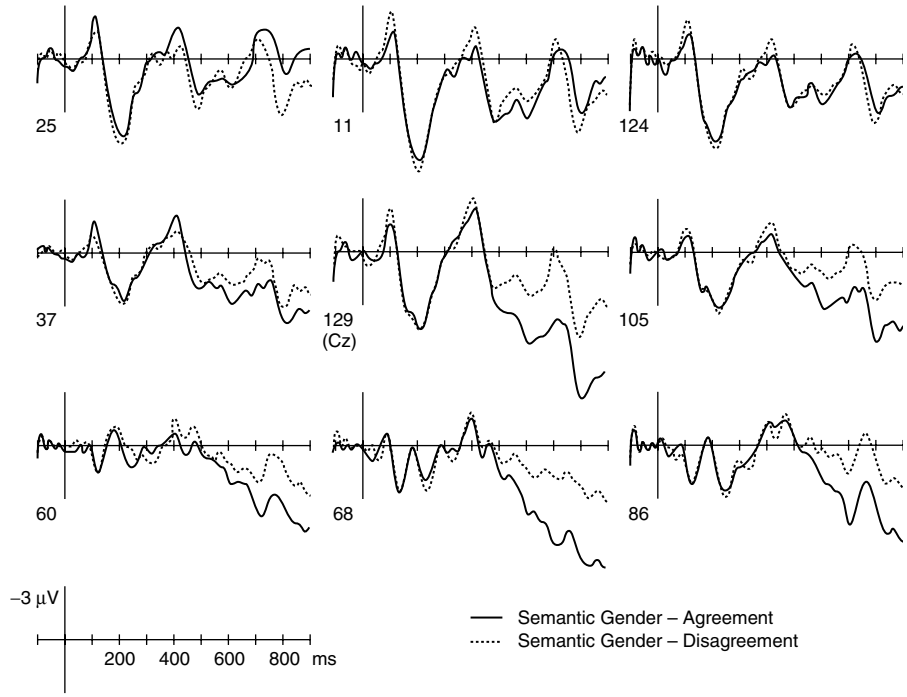

Figure 15.3. Sentences with semantic gender in the agreement condition versus the disagreement condition.

The 700–900 window analysis showed an interaction between the factor *gender agreement* and the *electrode regions* in the midline analysis ($F_{2,22} = 36.76$; $p < .001$; $\varepsilon = .71$; with normalized data, $F_{2,22} = 21$; $p < .001$), as well as a three-way interaction between the factors *gender agreement, electrode regions,* and *hemisphere* in the lateral regions analysis ($F_{2,22} = 5.5$; $p < .01$; $\varepsilon = .77$), and the two-way interaction between *gender agreement and electrode regions* after the data normalization ($F_{2,22} = 4.38$ $p < .001$). This three-way interaction reflects the right-posterior distribution of the effect in this window. The factor *type of gender* did not show any reliable effects in this window.

15.2.1 Type of Gender Effect

The previous analyses have shown differences between sentences with grammatical gender and sentences with semantic gender only in the 500–700 window but this effect did not interact with the agreement violations. Figure 15.4 compares the waves of the two agreement conditions. These differ from each other in the 500–700 temporal window with the semantic condition amplitudes more positive than those of the grammatical condition. Comparison of the two disagreement condition waves can be found in Figure 15.5, showing a similar effect. Importantly, the *type of gender* effects present a different spatial distribution from the violation effects; they are bigger in the central and anterior electrodes. In addition, visual inspection of these

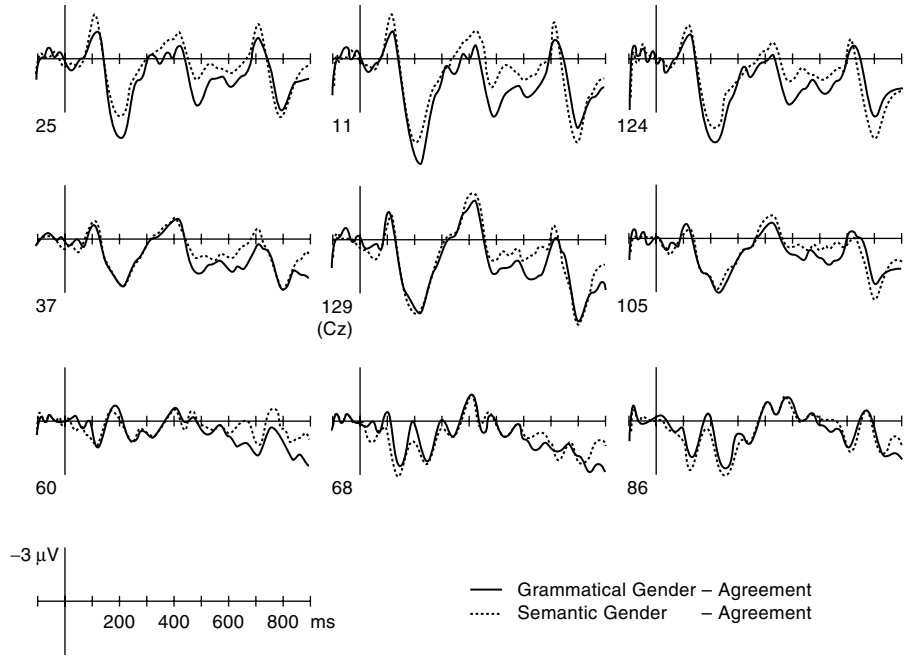

Figure 15.4. Well-formed sentences with only grammatical gender versus well-formed sentences with semantic gender.

figures suggests, in contrast with the *gender agreement* effect, that the onset of the *type of gender* effect could be slightly earlier, around 450 ms. In order to study this possible difference, additional analyses were performed using a short time window from 450 to 500 ms. Analysis in this window again indicated an interaction between the *type of gender* and the *electrode regions* factors both in the midline analysis ($F_{2,22} = 10.89$; $p < .001$; $\varepsilon = .65$) and in the lateral regions analysis ($F_{2,22} = 8.97$; $p < .01$; $\varepsilon = .61$), (normalized data, $F_{2,22} = 22$; $p < .01$ and $F_{2,22} = 3.68$; $p < .01$, respectively). However, in these latencies, there were no effects related with gender *agreement*.

15.3 DISCUSSION

The goal of this experiment was to investigate the role of semantic and morphosyntactic information associated with gender agreement processes. This was done by comparing sentences in which the gender of the noun was only a morphosyntactic characteristic with others in which the gender of the noun also implied conceptual information under two different conditions: well-formed sentences and sentences that violated gender agreement between the noun and the adjective. ERP comparisons showed two main results.

First, violations of both types of gender agreement produced two effects that have been typically associated with syntactic processes: a negativity around 400 ms

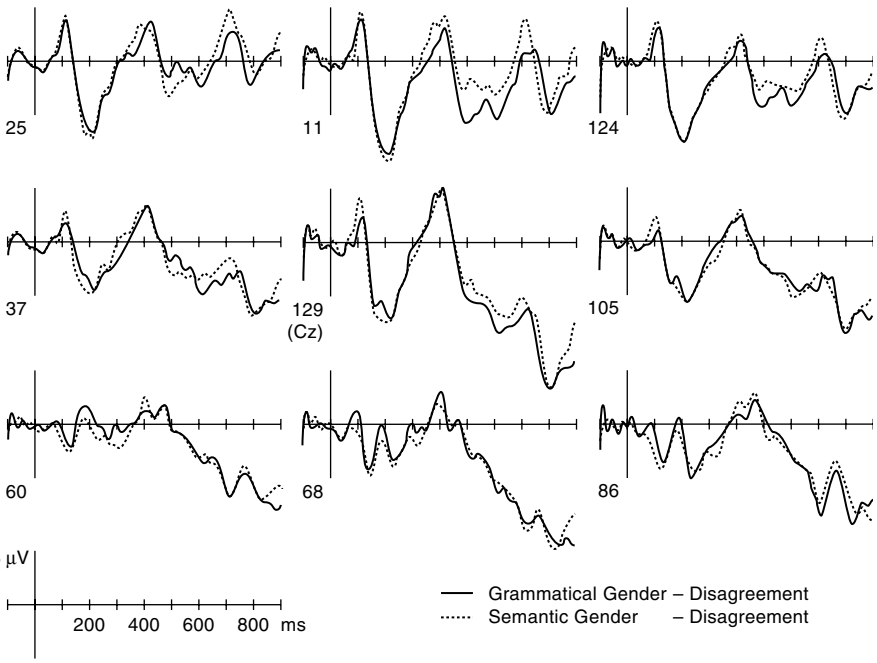

Figure 15.5. Ungrammatical sentences with only grammatical gender versus ungrammatical sentences with semantic gender.

with a left-anterior distribution that fits with the so-called LAN, and an inverse polarity effect that begins around 500 ms and stays for more than 400 ms, which corresponds with the P600. The distribution of the P600 effect until 700 ms is symmetrical in the central and posterior areas, and from that point on it is slightly lateralized towards the right side in the posterior areas. The magnitude of these effects was equivalent for the violations of both kinds of genders.

Second, there were differences between the waves of morphosyntactic gender and semantic gender conditions, both when there was a violation of agreement and when the sentence was well-formed. These differences were reliable between 450 ms and 700 ms and more prominent in the anterior areas. The effect of gender-type and the first phase of P600, although simultaneous in time, presented different distributions across electrodes and were additive in the central areas. The fact that these effects were independent suggests that they may reflect the operation of different processes, which allows us to consider them separately.

15.3.1 Agreement Violations Effects

According to previous interpretations, the LAN effect could be reflecting the detection of a mismatch between the features of the target word (the adjective) and those of the preceding NP (Münte, Matzke, & Johannes, 1997), the difficulty of integrating these characteristics in a syntactic structure (Gunter et al., 2000), or an increase of memory demand implied in these processes (Coulson, King, & Kutas, 1998). In a similar way,

the P600 could also reflect the impossibility of a later processing of syntactical integration (Osterhout & Mobley, 1995), the reanalysis and repair processes (Gunter et al.), or a more general activation process associated to anomaly detection (Coulson et al.). In any case, it seems that there is considerable evidence that these two effects are sensitive to manipulations of sentence syntax.

Some behavioral data point to the implication of semantic information in agreement processes (e.g., Deutsch et al., 1999), and some approaches propose continuous interaction between gender and semantic information during language comprehension (Bates, Devescovi, Hernandez, & Pizzamiglio, 1996). The N400 effect has been associated with difficulties in integrating lexical-semantic information, appearing in response to the disruption of conceptual coherence or of the expectations generated during language comprehension (Kutas & Federmeier, 2000). It could be thought that semantic gender information is involved in meaning integration processes during the agreement process, and so semantic gender mismatch could result in an increase in the amplitude of the N400. In fact, this result was reported by Deutsch and Bentin (2001). In an experiment in Hebrew, they presented sentences similar to those of the present study in which agreement between NP and predicate was or was not violated at the same time as subject animacy was manipulated. They found effects on the N400 only when semantic gender agreement was violated. Our data show differences around 400 ms but with a left-anterior distribution, whereas an overlapping between the agreement condition waves and those of disagreement was found in the areas where the N400 component is usually obtained, which suggests that there does not seem to be any modulation of this component. Although Spanish and Hebrew are languages with a richly inflected morphology in which agreement plays a relevant role in building the syntactic structure, there are important differences between the gender systems of both languages that could be producing this discrepancy in the results. In a similar way, Schmitt et al. (2002) reported an N400 effect when semantic gender agreement was violated, but in this work they manipulated anaphoric coreferences that involved long-distance relationships and discourse integration processes, so it is difficult to establish an adequate comparison with our design. In any case, our results fit better with other studies that did not find the N400 effect in gender agreement violations when these implied semantic gender (e.g., Osterhout & Mobley, 1995; Osterhout et al., 1997; Demestre et al., 1999). In this sense, the work of Osterhout et al.that has previously been mentioned is important, in that the nonagreement with the stereotypical gender of the subject produced an effect on the P600 but no effect on the N400. A semantic effect could also be expected because the stereotype associated with the subject of the sentences generated a pragmatic expectation about the gender of the reflexive pronoun that was afterwards violated. Therefore, these results also suggest that semantic information of gender does not seem to be implicated in the agreement process.

Even if semantic gender agreement does not trigger semantic integration processes, another possibility is that it affects syntactic agreement processes at later times. In the case of the P600, Gunter et al. (2000) points out that late syntactic integration processes can be modulated by the previous semantic processes. Nonetheless, the present results do not sustain that semantic gender information is involved in syntactic agreement processes because there was no influence of the semantic characteristics of gender on

processes related to syntactic integration, reanalysis, or detection of the nonagreement. The magnitude of the LAN and P600 effects was the same when agreement was violated with an animate subject with semantic gender or with a nonanimate subject with grammatical-only gender. Therefore, our data do not indicate any implication of semantic information in the detection and reanalysis processes of agreement violations, supporting previous claims that gender agreement is exclusively a syntactically driven process (Osterhout & Mobley, 1995; Hagoort & Brown, 1999).

In order to explain the exclusively syntactic nature of agreement processes, we should consider that agreement is based on the matching of gender features of the same nature between two words. In Spanish, as in other languages, determiners, adjectives and pronouns by themselves lack gender semantic characteristics, assuming the gender form of the noun they agree with.[3] In other words, only nouns actually have independent semantic gender characteristics. The integration of semantic gender characteristics is impossible when only one of the parts has these characteristics. Consequently, even in languages in which grammatical gender is almost nonexistent, as in English, the words with semantic gender (even stereotypically) need to have associated autonomous features of grammatical gender that could agree with other words such as pronouns that by themselves lack specific semantic referents.

15.3.2 Type of gender effect

The other intriguing effect is the type of gender. Our data have shown differences in the voltages associated with the adjective when the NP was animate as compared to when it was inanimate, independently of whether there was a grammatical violation of agreement. These differences were found between the 450 and 700 ms with an anterior distribution.

The fact that semantic gender information is not playing a differential role in the agreement process does not mean that such information could not be recovered or activated at the same time as syntactic agreement occurs. Independently of syntactic structure construction, this information is valuable for the creation of a representation of the message because the completion of the meaning of the adjective requires consideration of the information from the noun. Activation of the semantic gender information would not necessarily imply the triggering of agreement in a strict sense (see preceding text), because the adjective would passively assume the semantic gender characteristics of the NP. The effects obtained could reflect the demands of activating the gender information of the noun or of creating a new representation. This representation would have to consider the attributes of semantic gender but not necessarily those of the grammatical gender. For example, if we imagine *a thin grandfather*, the mental representation we would generate will include the attributes of the adjective *thin* applied to a concrete subject (i. e., elderly person) with specific male sex characteristics. On the contrary, the mental representation in the case of an inanimate object, for example, the case of *the high lighthouse,* does not need to incorporate any gender attribute apart from that necessary for establishing agreement. Thus, the present type of gender effect could be related with the differential activation of the information per se, or with the creation of a semantic representation rather than with a matching or agreement syntactic process.

On the other hand, taking into account that the presence of semantic gender is correlated with the animacy of the subject in our sentences, it could be argued that the effect was a more general process of animacy in sentence processing. Some previous studies show that animacy is a characteristic of nouns that is processed very early. ERP changes around 250 ms after the onset between animate and inanimate nouns have been previously observed (Weckerly & Kutas, 1999). Therefore, the differences described in the adjective could have begun much earlier in the sentence, even from the reading of the noun. For this reason, additional analyses were performed using long segments that included all the words from the beginning of the sentence to the word after the adjective, but these analyses failed to find any difference in the words previous to the adjective. Therefore, in our data, the gender effect is associated with processes that occur not earlier than after reading the adjective, and thus, it seems that they refer to activation of semantic gender information—for example, animacy as one of the features associated with semantic gender—rather than different demands in the maintenance of that information.

To sum up, the two main findings reported in the present paper are: (a) both semantic and morphosyntactic gender agreement processes produced LAN and P600 effects, showing that agreement is mainly a syntactic process; (b) differences in the time window from 450 to 700 ms with an anterior distribution were found between semantic and morphosyntactic gender, but they did not affect the agreement processes. Although we cannot be precise about the functional origin of the differences produced by gender type, we propose that they are related to differential gender information activation processes but independent of grammatical agreement processes, or, at least, of those processes involved in the detection and repair of violations which appear to be of a purely syntactic nature and are not affected by semantic gender information.

Further research is needed to investigate whether differences between semantic and morphosyntactic gender representation-activation still occur independently of animacy, what the nature of such differences is, and whether semantic gender influences the agreement process differently in other, more complex structures.

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Notes

1. It is important to distinguish semantic violations from violation of semantic gender. In this second case we are referring to a gender violation which involves semantic gender in contrast to grammatical gender.
2. Under some circumstances it is possible to dissociate animacy and semantic gender such as in the case of some animals (e.g., *perdiz* [partridge]). However, these variables cannot be dissociated when referring to human beings.
3. Although in our stimuli this circumstance does not happen, there are some adjectives that are statistically or stereotypically associated with referents of one particular sex (for instance: the adjective "bearded" is closely associated with men). In this case, the integration of the adjective with an animate noun may imply the integration of the features associated with the semantic gender of the noun and the semantic characteristics associated to the adjective, and therefore a mismatch between these could produce effects on the N400 (i. e., "the girl is bearded"). However, it should be noted that this effect would be a purely semantic one without any need for grammatical gender violation.