Note: Snapshot PDF is the proof copy of corrections marked in EditGenie, the layout would be different from typeset PDF and EditGenie editing view.

Author Queries & Comments:

Q1 : Please note that the ORCID has/have been created from information provided through CATS. Please correct if this is inaccurate.

Response: I.Fraga's and J.A. Hinojosa's ORCID are correct. Please, add I. Padrón's ORCID number, which is: 0000-0002-2796-3531

Q2 : Please provide missing city for affiliation.

Response: Santiago de Compostela

Q3 : The funding information provided (Ministerio de Economía y Competitividad (MINECO) of Spain) has been checked against the Open Funder Registry and we found a partial match with "Ministerio de Economia y Competitividad". Please check and resupply the funding details.

Response: Resolved

Q4 : The funding information provided (Ministerio de Ciencia, Innovación y Universidades of Spain) has been checked against the Open Funder Registry and we found a partial match with "Ministerio de Ciencia e Innovacion". Please check and resupply the funding details.

Response: Resolved

Q5 : The reference "Tanner et al. 2014, 2019" is cited in the text but is not listed in the references list. Please either delete the in-text citation or provide full reference details following journal style.

Response: Resolved

Q6 : The disclosure statement has been inserted. Please correct if this is inaccurate.

Response: Resolved

Q7 : Please provide missing issue number for reference "Leikin and Breznitz 1999" references list entry.

Response: The complete reference is: Leikin, M., & Breznitz, Z. (1999). Syntactic Processing of Hebrew Sentences: ERP Measures. Genetic, Social, and General Psychology Monographs, 125(2), 173.

Q8 : Please provide missing DOI, if available, for the "Leikin and Breznitz 1999" references list entry.

Response: There is no available DOI

CM1 : The words in brackets are correct. There are no changes here in relation to the previous draft, but we couldn't delete the orange colour.

CM2 : In the printed version, the content throughout the table is not aligned to the left, making it difficult to read the examples and so on

---

Negative valence effects on the processing of agreement dependencies are mediated by ERP individual differences in morphosyntactic processing

LANGUAGE, COGNITION AND NEUROSCIENCE

I. FRAGA ET AL.

I. Fraga[a][Q1], I. Padrón[a], J. A. Hinojosa[b,c,d]

[a] Cognitive Processes & Behaviour Research Group, Department of Social Psychology, Basic Psychology and Methodology, University of Santiago de Compostela, Spain[Q2]

[b] Instituto Pluridisciplinar, Universidad Complutense de Madrid, Madrid, Spain

[c] Dpto Psicología Experimental, Procesos Cognitivos y Logopedia, Universidad Complutense de Madrid, Madrid, Spain

[d] Centro de Ciencia Cognitiva - C3, Universidad Antonio de Nebrija, Madrid, Spain

CONTACT Isabel Fraga isabel.fraga@usc.es Dpto. de Psicoloxía Social, Básica e Metodoloxía, Facultade de Psicoloxía-Universidade de Santiago, Rúa Xosé María Suárez Núñez s/n. Campus sur, Santiago de Compostela 15782, Spain

History : received : 2020-6-11 accepted : 2021-4-19

ABSTRACT

Some previous ERP studies on the interaction between emotion and morphosyntactic processing have shown emotional modulations in a left anterior negativity (LAN) indexing the early detection of agreement mismatches, whereas others have failed to report such differences. Here we examined individual differences in the morphosyntactic processing of emotional words, which might account for the divergences found in previous studies. To this aim, neutral and negative adjectives in grammatically correct and incorrect noun phrases (NPs) were presented to 62 participants. The general analyses showed an emotionality effect in the N100 component as well as enhanced LAN and P600 amplitudes in mismatch trials. Further analyses confirmed that most participants showed either LAN (negativity dominance) or P600 (positivity dominance) effects. Importantly, these two groups exhibited different patterns over the time course. Overall, our data suggest that individual differences should be considered when investigating the interplay between emotion and morphosyntactic processing.

KEYWORDS

- Gender agreement
- emotional words
- event-related potentials
- LAN
- P600
- individual differences

FUNDING

This work was supported by Ministerio de Economía y Competitividad ~~(MINECO) of Spain~~ (PSI2015-65116-P), Ministerio de Ciencia, Innovación y Universidades (PGC2018-098558-B-I00), Ministerio de Ciencia e Innovación ~~and~~ (PID2019-110583GB-I00) of Spain, **[Q3]**Xunta de Galicia (ED431B 2019/2020), ~~Ministerio de Ciencia, Innovación y Universidades of Spain (PGC2018-098558-B-I00),~~ and the **[Q4]**Comunidad de Madrid (H2019/HUM-5705).

Introduction

From a neurobiological point of view, research on the neural underpinnings of the interaction between language and emotion has focused mainly on the influence of emotional content in word processing, looking at a variety of aspects here, such as lexical access (Mendez-Bertolo et al., 2011; Nakic et al., 2006; Palazova et al., 2011; Scott et al., 2009) or the relationship between emotion and other semantic properties (e.g. concreteness: Kanske & Kotz, 2007; Palazova et al., 2013; Vigliocco et al., 2014; see Citron, 2012; Hinojosa et al., 2020; Kissler et al., 2006 for reviews). The effects of the emotional properties of words on the combinatorial processes involved in sentence comprehension remain less well understood. Most studies investigated how emotional features modulate prediction and integration mechanisms underlying semantic unification processes (e.g. Cao et al., 2019; Delaney-Busch & Kuperberg, 2013; Ding et al., 2020; Moreno & Rivera, 2014; see Molinaro, 2020 for an overview). Recently, a small number of event-related potential (ERPs) studies have addressed the role of emotional content in the establishment of structural dependencies between sentence constituents based on morphosyntactic cues, with a particular focus on number and gender features. As we will show later, current findings are controversial, with some studies pointing to effects of emotional content in the computation of agreement relations (Hinojosa et al., 2014; Jiménez-Ortega et al., 2017; Martín-Loeches et al., 2012), while others failed to observe such modulations (Díaz-Lago et al., 2015; Fraga et al., 2017; Padrón et al., 2020). In the current event-related potentials (ERPs) study we will further examine emotional effects on the processing of agreement relationships. In particular, based on recent findings pointing to the existence of individual variations in grammatical agreement processing (Tanner, 2019; Tanner & Van Hell, 2014), we will investigate whether these individual differences account for the inconsistent interactions between emotion and morphosyntactic processes.

Parsing operations for establishing agreement dependencies based on the covariation of the inflectional morphology shared by sentence elements (e.g. nouns and verbs, determiners and adjectives …) are fundamental for language understanding. These rule-based operations involve processes in which incoming words and constituents are combined with an unfolding partial phrase marker by means of the variation of formal features such as person, number or gender (Corbett, 2006; Hagoort, 2005; Wechsler, 2009). Using tasks in which participants judged sentences for grammar errors [e.g. *La chica$_{sg}$ fea$_{sg}$/*feas$_{pl}$ baila (the ugly$_{sg}$/ugly$_{pl}$ girl$_{sg}$ dances)*], several ERP studies have observed two components during the on-line processing of agreement relations (e.g. Barber & Carreiras, 2005; Hinojosa et al., 2003; Osterhout & Mobley, 1995; see Molinaro et al., 2011 for a review). The early detection of agreement mismatches between two sentence constituents elicits enhanced amplitudes in an early left anterior negativity (LAN) peaking between 250 and 500 ms at left frontal scalp locations. Subsequently, a late posterior positivity (P600) with an onset of around 500 ms at parieto-occipital electrodes has been linked to reanalysis and repair processes triggered by the difficulty in integrating agreement errors into prior sentence contexts (Kuperberg, 2007).

Studies that have explored the effects of emotion on morphosyntactic processing have used a dimensional theoretical framework of emotions (Lang et al., 1990; Russell, 1980), in which emotions can be characterised by two orthogonal dimensions, valence (the extent to which an emotion is positive/pleasant or negative/unpleasant) and arousal (the degree of intensity or activation from calming to exciting). These studies, whose main characteristics are set out in Table 1, have consistently failed to report modulations in the amplitude of the P600 due to the emotional content of words, since gender and number agreement anomalies in negative, positive and neutral words always elicited similar amplitude enhancements compared to grammatically correct sentences (Díaz-Lago et al., 2015; Fraga et al., 2017). However, the influence of emotion on the early detection of agreement errors, as indexed by modulations in the LAN component, is less conclusive. Three studies reported effects of emotional processing during the computation of agreement relationships based on either number or gender features. In this sense, Martín-Loeches et al. (2012) used sentences [determiner-noun–adjective-verb] containing positive, negative, or neutral adjectives that either matched or mismatched the number of the preceding noun. The authors reported larger LAN amplitudes, between 350 and 450 ms, for the number anomalies in the negative condition, indicating increased processing costs for the computation of agreement relationships in negative adjectives. Also, Hinojosa et al. (2014) manipulated gender agreement relationships between negative or neutral adjectives following a noun in correct and grammatically incorrect NPs [determiner–-noun–adjective]. Gender agreement errors in neutral adjectives elicited enhanced LAN amplitude in the 250–450 ms time-window, whereas no differences were observed between match and mismatch conditions for negative adjectives. Since LAN effects have been related to the detection of morphosyntactic errors, the authors concluded that the absence of such effects in the negative content condition could be related to a facilitated identification of gender agreement anomalies. Similar findings were reported by Jiménez-Ortega et al. (2017), who aimed at investigating the effects of masked negative, positive and neutral adjectives on the processing of agreement dependencies between the sentence subject and a modifier [determiner-noun (lexical subject)-subliminal adjective + mask-adjective (modifier)-verb]. In the mismatch condition, half sentences contained either number or gender agreement anomalies between the lexical subject and the modifier, whereas agreement between the masked adjective and the preceding noun always matched. In the 500–600 ms time-window, agreement anomalies elicited a LAN component when the masked adjective between the lexical subject and the modifier was neutral.[1] Notably, the LAN effects in the error condition vanished when a negative masked adjective was inserted between the lexical subject and the modifier. The results of these studies support interactive approaches to language comprehension in which the processing of semantic (emotional) and morphosyntactic features interact during early computation of agreement dependencies. In contrast, the results of three studies argue for a modular view since they did not show LAN modulations by emotion during the processing of agreement dependencies. Díaz-Lago et al. (2015) used sentences with a lexical subject-verb-direct object structure. The direct objects were NPs containing positive or neutral adjectives that in terms of gender either matched or mismatched agreement features with the preceding noun. LAN effects of a similar size between 350 and 450 ms were found in the mismatch condition for both positive and neutral adjectives. In further studies using sentences with the same structure (Fraga et al., 2017; Padrón et al., 2020), the authors failed again to find differences in the amplitudes of the LAN component (between 350 and 450 ms) elicited by negative and neutral adjectives (Fraga et al., Exp. 1), by negative, positive and neutral adjectives (Fraga et al., Exp. 2), or by negative and positive adjectives (Padrón et al., 2020).

Table 1. Methodological details and ERP results of the main studies reviewed in this article.

Study	Linguistic Unit	Examples of match and mismatch sentences (target word in bold)	Task	Word valence (valence and arousal values in parentheses)	N100 EPN	Time Windows (350–450 ms)			Time windows (500–800 ms)	
					Emo.	Gram.	Emo.	Gram. × Emo.	Gram.	Emo.
Martín-Loeches et al. (2012, Exp.1)	Short sentences [det/noun/adj/verb]	La hermana **querida/s** acude. El espejo **ovalado/s** refleja. La chica **fea/s** baila.	Number agreement task	Pleasant (7.2; 3.2) Neutral (5.1; 2.3) Unpleasant (3.0; 3.3)	-	LAN: mismatch sentences > match sentences.	-	LAN: neutral mismatch sentences = neutral match sentences; unpleasant mismatch sentences > unpleasant match sentences	P600: mismatch sentences > match sentences.	-
Hinojosa et al. (2014)	NPs [det/noun/adj]	El camarero **rubio/a**. El camarero **furioso/a**.	Gender agreement task	Neutral (5.2; 4.1) Unpleasant (2.1; 6.9)	-	LAN: mismatch sentences > match sentences.	-	LAN: neutral mismatch sentences > neutral match sentences; unpleasant mismatch sentences = unpleasant match sentences	P600: mismatch sentences > match sentences.	-
Díaz-Lago et al. (2015)	Long sentences [det/noun/verb/direct obj (det/noun/adj)/ ...]	La joven se comió una hamburguesa **tierna/o** con patatas. Elena colocó la mesa **cuadrada/o** en el centro del salón.	Gender agreement task	Pleasant (7.6; 5.7) Neutral (5,1; 4.8)	N100-P100: pleasant sentences > neutral sentences	LAN: mismatch sentences > match sentences.	-	-	P600: mismatch sentences > match sentences.	LPC: pleasant sentences > neutral sentences
Fraga et al. (2017, Exp.1)	Long sentences [det/noun/verb/direct obj (det/noun/adj)/ ...]	Sabrina fue una pintora **famosa/o** en sus tiempos. Tania tiró un pescado **podrido/a** que estaba en la nevera.	Gender agreement task	Neutral (4.9; 4.8) Unpleasant (2.4; 6.1)	-	LAN: mismatch sentences > match sentences.	-	-	P600: mismatch sentences > match sentences.	-

Fraga et al. (2017, Exp.2)	Long sentences [det/noun/verb/direct obj (det/noun/adj)/ …]	Natacha es una doctora **honesta/o** con sus pacientes. El arqueólogo encontró un cuenco **raro/a** durante la excavación. El restaurante ofrecía una cocina **penosa/o** de bajo nivel.	Gender agreement task	Pleasant (7.6; 5.7) Neutral (4.9; 4.8) Unpleasant (2.4; 6.1)	-	LAN: mismatch sentences > match sentences.	-	-	P600: mismatch sentences > match sentences.	-
Jiménez-Ortega et al. (2017)	Short sentences [det/noun/subl. adj/mask/adj/verb]	El dinero **regalado** [suelto/a] tintinea. El dinero **contado** [suelto/a] tintinea. El dinero **falso** [suelto/a] tintinea. La norma **justa** [escrita/s] regula. La norma **creada** [escrita/s] regula. La norma **violada** [escrita/s] regula.	Gender and number agreement task	Pleasant (7.1; 4.9) Neutral (5.7; 4.9) Unpleasant (3.1; 6.3)	-	LAN: mismatch sentences > match sentences.	-	LAN: neutral mismatch sentences > neutral match sentences; unpleasant mismatch sentences = unpleasant match sentences.	P600: mismatch sentences > match sentences.	LPC: pleasant and unpleasant sentences > neutral sentences.
Padrón et al. (2020)	Long sentences [det/noun/verb/direct obj (det/noun/adj)/ …]	El chico pintó un cuadro **hermoso/a** para su novia. Luis conducía por una carretera **abandonada/o** sin asfaltar.	Gender agreement task	Pleasant (7.6; 5.7) Unpleasant (2.4; 6.1)	-	LAN: mismatch sentences > match sentences.	N400: unpleasant sentences > pleasant sentences	-	P600: mismatch sentences > match sentences.	-

The data summarised here suggest that further work is needed to identify those factors that account for discrepancies in the results across studies. While differences in the representation of gender (an intrinsic syntactic property) and number (a conceptual property that indicates the quantity of the referent) features might explain the impaired detection of gender anomalies (Hinojosa et al., 2014) relative to the facilitated identification of number errors (Martín-Loeches et al., 2012), the variety of effects observed in studies that manipulated gender agreement is more difficult to interpret (see Fraga, 2020 and Hinojosa et al., 2020 for a detailed discussion). Briefly, differences in the structure of stimulus materials have been suggested as a possible explanation for the presence (noun phrases in semantically unconstrained contexts in Hinojosa et al., 2014) or the absence (noun phrases embedded in sentences in Díaz-Lago et al., 2015; Fraga et al., 2017 and Padrón et al., 2020) of emotion effects in the processing of gender agreement dependencies. Also, differences in the use of arbitrarily gendered nouns (e.g. *dinero*$_m$/*money*; Díaz-Lago et al., 2015; Fraga et al., 2017; Padrón et al., 2020) and nouns denoting entities with biological referents (e.g. niña*f*/*girl*; Hinojosa et al., 2014) might partially account for divergent results. In this regard, prior ERP research has shown the existence of different routes to access aspects of gender information, such as lexical or formal cues (Caffarra et al., 2014).

An intriguing possibility that remains unexplored arises from recent evidence indicating that individual variability in ERP responses to agreement violations plays a critical role in early morphosyntactic processing. In this sense, Tanner and Van Hell (2014) observed biphasic LAN-P600 effects in the grand averages of participants that read ungrammatical sentences with morphosyntactic errors (subject-verb number agreement anomalies and violations of constraints in verb tense). However, the results of additional analyses indicated that even though most individuals showed a reliable P600 component, only 35% of the participants showed biphasic LAN-P600 responses. By computing a Response Dominance Index (RDI), the authors found that individuals typically showed a negativity-dominant or a positivity-dominant response profile rather than biphasic effects. Accordingly, those participants who showed large P600 amplitudes tended to show small LAN effects and vice versa. Based on their findings, the authors concluded that biphasic effects could result from averaging across participants who differed in ERP responses to morphosyntactic errors (see also Tanner, 2015, 2019). Similarly, Caffarra et al. (2019)

found that only 55% of their participants showed LAN effects while they read sentences that contained article-noun gender agreement anomalies, although the study failed to report a strong relation between LAN effects and the subsequent P600 effects in individual participants. All in all, such findings leave open the possibility that the inconsistent results from previous studies examining the role of emotional content in the computation of agreement dependencies reflect individual differences in the ERP responses elicited by morphosyntactic anomalies.

In the current study our first aim is to replicate emotion effects found in the processing of gender agreement relationships in low semantically constrained structures (like those used in Hinojosa et al., 2014). Additionally, although the LAN and the P600 are the main components of this study, two early emotional components, N100 and Early Posterior Negativity (EPN), are also explored. These negative deflections typically show enhanced amplitudes for emotional words relative to neutral ones at posterior electrodes around 100 ms (N100) or between 200 and 300 ms (EPN) (Bernat et al., 2001; Hofmann et al., 2009; Kissler et al., 2006; Scott et al., 2009). The N100 is thought to reflect an initial advantage in rapidly and selectively processing emotional information, whereas the EPN has been related to an early stage of automatic attention allocation to the intrinsically relevant emotional features of words (Citron, 2012; Hinojosa et al., 2020).

Secondly, to investigate whether these effects can be reliably observed across participants, or simply arise from averaging ERP responses from a subset of individuals who differed in brain responses (Tanner & Van Hell, 2014), we collected data from a large set of participants (n = 62) while they performed a grammatical judgement task, in which neutral and negative adjectives that either agreed or disagreed in gender with a previous neutral noun were embedded in NPs [(Determiner + Noun (lexical subject) + Adjective (modifier)]. Crucially, after calculating the RDI scores we conducted separate analyses for those individuals showing negative-dominant and positive-dominant ERP responses. In addition to their importance for the field of affective neurolinguistics, the results of the present study might also have important implications for the debate between modular views that conceive morphosyntactic processing as being encapsulated (Fodor, 1983) and those frameworks postulating interactions between different levels of linguistic representation (Trueswell et al., 1994; Vosse & Kempen, 2000). Additionally, the current data might serve to shed light on the individual variability of the early morphosyntactic processes indexed by the LAN component (Caffarra et al., 2014; Tanner & Van Hell, 2014).

Materials and methods

Participants

Sixty-two Spanish native speakers from the University of Santiago de Compostela (17 men, 45 women) between 19 and 24 years old (Mean age = 20.18, *SD* = 1.23) participated in this study. All volunteers were right-handed according to the Edinburgh Handedness Inventory (Oldfield, 1971). They had normal or corrected-to-normal vision and no history of neurological disorders were reported. All the participants gave written informed consent to participate in the study and they were rewarded with course credits. Six participants were eliminated from the analyses due to excessive noise/artefacts in the EEG register, and thus the final sample comprised fifty-six participants.

Materials

A set of 128 experimental NPs was constructed with the following structure: Determiner + Noun + Adjective (critical word). For the creation of experimental NPs, 64 neutral nouns and 64 adjectives (32 neutral and 32 unpleasant) were used. We manipulated the gender of the adjectives in order to generate the conditions of agreement (a grammatical, match condition versus an ungrammatical, mismatch condition) with the precedent noun, as well as the emotionality of the adjectives, which could be neutral or unpleasant. All adjectives were presented in their feminine and masculine versions, and all had the canonical ending suffixes ("o" for masculine and "a" for feminine; e.g. "abandonado" / "abandonada" [abandoned]).

The nouns and adjectives were selected from several Spanish databases using the emoFinder (Fraga et al., 2017) and B-Pal (Davis & Perea, 2005) tools. Additionally, we conducted an on-line survey to collect valence, arousal and concreteness ratings that were not available for some masculine or feminine versions of several nouns and adjectives. Forty participants (27 females, 13 males; Mean age = 26.1, SD = 4.75) who did not participate in the ERP experiment completed one of two lists composed of 130 words. We employed a 9-point Likert scale for the valence and arousal dimensions (9 being highly pleasant and highly arousing, respectively) and a 7-point Likert scale for concreteness (1 being highly abstract and 7 being highly concrete).

The selected neutral nouns had intermediate levels of valence (*M* = 5.19) and arousal (*M* = 4.87). Also, neutral adjectives had intermediate levels of valence (*M* = 5.33) and arousal (*M* = 5.21) scores. Finally, unpleasant adjectives had low valence scores (*M* = 2.90) and moderate arousal scores (*M* = 5.85). All adjectives (in their masculine and feminine versions) differed in the emotional dimensions (that is, valence and arousal) but had similar scores in concreteness, word length and frequency of use. A 2 × 2 (Gender and Emotionality) analysis of variance (ANOVA) was conducted for each variable to assess these differences (see Table 2).

Table 2. Means (and SDs) of valence (1 = highly unpleasant, 9 = highly pleasant), arousal (1 = highly calming, 9 = highly arousing) No. of letters, No. of syllables, frequency and concreteness (1 = highly abstract, 5 = highly concrete) for the neutral and unpleasant adjectives used in the experiment.

		Valence	Arousal	Letters	Syllables	Frequency	Concreteness
Neutral	Feminine	5.29 (0.87)	5.20 (0.77)	8.00 (1.81)	3.53 (0.88)	0.62 (0.53)	4.13 (0.62)
	Masculine	5.38 (0.82)	5.22 (0.99)	8.00 (1.81)	3.53 (0.88)	0.62 (0.44)	4.33 (0.92)
Unpleasant	Feminine	2.91 (0.58)	5.60 (0.84)	7.97 (2)	3.50 (0.88)	0.55 (0.32)	3.99 (0.59)
	Masculine	2.89 (0.58)	6.01 (0.94)	7.97 (2)	3.50 (0.88)	0.57 (0.29)	4.36 (0.67)
ANOVA							
Emotionality		*F* = 219.29*	*F* = 9.43*	*F* = 0.00[ns]	*F* = 0.02[ns]	*F* = 0.35[ns]	*F* = 0.15[ns]
Gender		*F* = 0.19[ns]	*F* = 3.56*	*F* = 0.00[ns]	*F* = 0.00[ns]	*F* = 0.16[ns]	*F* = 8.52*

Emotionality × Gender		*F* = 0.53[ns]	*F* = 2.96[ns]	*F* = 0.00[ns]	*F* = 0.00[ns]	*F* = 0.00[ns]	*F* = 0.76

(*g.l.* = 1,62; n.s.: no significant, *p < .01).

A different sample of participants (41 participants, 35 females, 6 males; Mean age = 19.90, SD = 1.24) completed one of two versions of a questionnaire (with 128 NPs each) to score cloze probabilities for the critical adjectives in the NPs. Participants were asked to write the most likely expected word that they thought would follow each NP (determiner + noun). This procedure aimed to check that the critical adjectives in our study could not be predicted based on the preceding context.

In order to avoid repetition effects, four experimental lists were performed. Thus, every list included 32 NPs belonging to each of the four experimental conditions (neutral match, unpleasant match, neutral mismatch, and unpleasant mismatch). As noted above, half of the adjectives were feminine, and half were masculine. Each list was randomly assigned to 14 participants. The NPs in each version were presented in a pseudo-random order, with no more than four NPs of the same condition presented in succession (see Table 3).

Table 3. Examples of unpleasant and neutral match and mismatch NPs.

		Match	Mismatch
Neutral	Feminine	La abogada$_{(fem)}$ meticulosa$_{(fem)}$	La abogada$_{(fem)}$ meticuloso$_{(masc)}$
		The meticulous$_{(fem)}$ lawyer$_{(fem)}$	*The meticulous$_{(fem)}$ lawyer$_{(masc)}$*
	Masculine	El abogado$_{(masc)}$ meticuloso$_{(masc)}$	El abogado$_{(masc)}$ meticulosa$_{(fem)}$
		The meticulous$_{(masc)}$ lawyer$_{(masc)}$	*The meticulous$_{(masc)}$ lawyer$_{(fem)}$*
Unpleasant	Feminine	La abogada$_{(fem)}$ agresiva$_{(fem)}$	La abogada$_{(fem)}$ agresivo$_{(masc)}$
		The aggresive$_{(fem)}$ lawyer$_{(fem)}$	*The aggresive$_{(fem)}$ lawyer$_{(masc)}$*
	Masculine	El abogado$_{(masc)}$ agresivo$_{(masc)}$	El abogado$_{(masc)}$ agresiva$_{(fem)}$
		The aggresive$_{(masc)}$ lawyer$_{(masc)}$	*The aggresive$_{(masc)}$ lawyer$_{(fem)}$*

We also included 112 filler NPs with the same structure as the experimental NPs. Similarly to Hinojosa et al.'s study, we included a set of 38 NPs with adjectives with a neutral suffix, which is applied indistinctly to both masculine and feminine gender nouns (e.g. "-e"; "triste" [sad]), 37 NPs containing nouns with opaque gender, that is, without any explicit morphological mark, (e.g. "lápiz", [pencil]), and 37 NPs with irregular nouns (e.g. "mano" [hand] ends with the letter "-o" but is feminine). Fillers of this type were included to avoid the situation in which participants might use a superficial strategy to solve the task, such as focussing exclusively on canonical ending suffixes ("o" for masculine and "a" for feminine). Half of the fillers included negative adjectives and half included neutral adjectives. In addition, half were grammatically correct and half incorrect. In total, each participant received 240 phrases.

Procedure

Participants performed the behavioural task in an enclosed and dimly illuminated room. After each participant signed the informed consent and filled out the Spanish version of the Edinburgh Handedness Questionnaire, they were randomly assigned to one of the four stimulus lists. Words were shown (one by one) in the centre of the screen of a PC monitor 65 cm from the participant's eyes. A chin rest was used to avoid head movement and to maintain this distance. All words were presented in black colour on a grey background with a font size of 30, Chicago typeface. Participants performed the grammaticality judgement task. They were asked to indicate whether the phrases were syntactically correct or incorrect by pressing one of two buttons with either the middle or index finger (the assignment of the buttons was counterbalanced across participants).

Each trial began with a 1000 ms fixation cross on the centre of the screen. Then, after a blank screen interval of 100 ms, each NP was displayed word by word with a 300 ms interval between words, plus 300 ms of inter-stimulus interval. One hundred milliseconds after the offset of the final word, three question marks were presented for 2500 ms indicating to the participants that they should give their response. If no answer was produced within this time span, the next trial began. The inter-trial interval was 500 ms. Before the experimental trials, a training block of six phrases was presented.

Once participants had completed the task, they rated the NPs on valence and arousal dimensions (using an adaptation of the 1–9 scale *Self-Assessment Manikin* (SAM; Bradley & Lang, 1994)), and plausibility (using a 1–5 Likert-scale; 1 being low, 5 being high). Each individual session took about 90 min.

Electrophysiological recording and analyses

Electroencephalogram (EEG) activity was recorded from 32 active electrodes embedded in an elastic cap (Electro-Cap International, Inc.) with a *Quickamp* amplifier. Electrode locations were: Fp1, Fp2, F3, Fz, F4, F7, F8, C3A, CzA, C4A, C7A, C8A, C3, Cz, C4, C3P, C4P, T3, T4, T5, T6, T3L, T4L, PzA, P3, Pz, P4, O1, Oz and O2. The average right and left earlobes served as reference and an electrode placed between the Fpz and Fz positions was used as the ground. Vertical electro-oculogram (VEOG) was recorded for artifact monitoring from two electrodes placed below and above the right eye orbital. Electrode impedances were kept below 10 kΩ. The EEG signal was continuously recorded with a frequency band-pass of 0.01-30 Hz at a sampling rate of 500 Hz.

EEG data was processed using the *Brain Vision Analyzer® 2.3* software (Brain Products, Germany). Recordings were re-referenced off-line to right and left earlobes average and a band-pass filter from 0.1 to 30 Hz (24 dB/oct.) was used. Separate EEG epochs of 1100 ms (200 ms pre-stimulus baseline) were extracted offline for critical adjectives. Only segments with correct responses were further analysed. Ocular artifacts (blinks and eye movements) were corrected using the method described by Gratton et al. (1983). Epochs with voltage values +-/100 mV were automatically rejected. Following baseline correction, epochs were averaged separately for all experimental conditions (neutral match, neutral mismatch, unpleasant match, and unpleasant mismatch) and scalp positions. The final number of trials per condition was 28.25 (*SD* = 4.57) for neutral match, 28.34 (*SD* = 4) for neutral mismatch, 28.82

(*SD* = 3.56) for unpleasant match, and 28.52 (4) for unpleasant mismatch, with no differences among conditions *F*s(1,55) < 2.5. The minimum number of trials admitted for averaging was 20 per condition. To meet this criterion, the data from six participants were eliminated for analyses, and thus the final grand averages were computed for 56 participants.

ERP data analysis

Based on the results from previous work (Citron, 2012; Díaz-Lago et al., 2015; Fraga et al., 2017; Herbert et al., 2008; Hinojosa et al., 2014; Molinaro et al., 2011; Barber & Carreiras, 2005) and on visual inspection of the individual and grand average waveforms, we selected for further analysis the following time windows after the onset of the target word: 80-130 ms (for the N100 component), 200-300 ms (for the EPN component), 300-450 ms (for the LAN component) and 550-750 ms (for the P600 component). Mean amplitudes for these time windows were measured for each condition: neutral match, neutral mismatch, unpleasant match, and unpleasant mismatch. We selected five regions of interest (ROIs) by averaging the following electrodes sites: left anterior (LA: comprising Fp1, F3 and C3A electrodes), right anterior (RA: comprising Fp2, F4 and C4A electrodes), left-posterior (LP: comprising T3L, C3P, T5 and P3 electrodes), central-posterior (CP: comprising CZ, PZA and PZ electrodes), and right-posterior (RP: comprising T4L, C4P, T6 and P4 electrodes). Repeated measures ANOVAs with Grammaticality (match vs. mismatch), Emotionality (unpleasant vs. neutral) and ROI (LA, RA, LP and RP) as within-participants factors were performed for the 80-130 ms, 200–300 and 300-450 ms temporal windows. For the 500–750 time-window, a repeated measures ANOVAs with Grammaticality (match vs. mismatch), Emotionality (unpleasant vs. neutral) and ROI (LA, RA, LP, CP, RP) as within-participants factors were performed.

Regarding the analyses of the behavioural data, percentages of hits and reaction times (RTs) were included in repeated measures ANOVAs with Grammaticality (match vs. mismatch) and Emotionality (unpleasant vs. neutral) as within-participants factors.

For all ANOVAs post-hoc tests were Bonferroni-corrected. Where appropriate, the Greenhouse-Geiser correction for violations of the sphericity assumption was applied. Statistical analyses were carried out using the IBM *Statistica* software (version 10).

Results

Performance

The analyses of behavioural data revealed that participants were very accurate in detecting the morphosyntactic errors (98.2%, 97.5%, 98% and 98.5% for neutral match, neutral mismatch, unpleasant match and unpleasant mismatch conditions, respectively) without any differences regarding the Grammaticality and Emotionality of the NPs, *F*(1, 52) < 1. Moreover, participants showed lower RTs in the mismatch conditions (454 ms) than in the match conditions (468 ms), as reflected in a significant main effect of Grammaticality. No other significant effects were found, *Fs*(1, 52) < 1.5.

Subjective ratings

In order to assess the valence and the arousal of the NPs with unpleasant and neutral adjectives, two 2 × 4 × 2 (Emotionality [unpleasant, neutral] × List [list 1, list 2, list 3, list 4] × Gender [feminine, masculine] repeated measures ANOVAs were performed. Regarding valence, the analyses showed a main effect of Emotionality, $F_1(1, 52) = 326.30$, $p < .001$, $\eta_p^2 = .86$; $F_2(1, 31) = 453.49$, $p < .001$, $\eta_p^2 = .94$, indicating that, as expected, participants rated the NPs with neutral adjectives as more pleasant (M = 5.08) than the NPs with the unpleasant ones (M = 3.20); and a main effect of Gender, $F_1(1, 52) = 9.008$, $p < .01$, $\eta_p^2 = .14$; $F_2(1, 31) = 4.56$, $p < .05$, $\eta_p^2 = .12$, revealing that participants rated the NPs with feminine adjectives as more pleasant (*M* = 4.20) than the NPs with masculine adjectives (M = 4.08). Regarding arousal, statistical analyses showed, as expected, a main effect of Emotionality, $F_1(1, 52) = 47.96$, $p < .001$, $\eta_p^2 = .48$; $F_2(1, 31) = 328.05$, $p < .001$, $\eta_p^2 = .91$, indicating that participants rated the NPs with unpleasant adjectives as more arousing (M = 5.44) than the NPs with neutral ones (*M* = 4.67). The analyses on plausibility of the NPs only revealed a triple interaction of Emotionality, Gender and List, $F_1(3, 52) = 22.63$, $p < .001$, $\eta_p^2 = .56$; $F_2(3, 93) = 7.08$, $p < .001$, $\eta_p^2 = .18$, showing that the NPs with unpleasant feminine adjectives in List 3 were rated as less plausible (*M* = 3.67) than NPs with unpleasant masculine adjectives (*M* = 4.04).

ERP data

Early emotionality effects

Table 4 reports the results of the omnibus ANOVAs for the main time-windows. In the 80-130 ms time-window (N100 component), the statistical analysis revealed a main effect of ROI, with more pronounced N100 amplitudes in the left posterior and right anterior regions, and a marginally significant main effect of Emotionality that showed higher N100 amplitudes in the unpleasant condition (−1.22 µV) than in the neutral condition (−0.96 µV) (see Figure 1). In the 200-300 ms time window (EPN component), no significant effects or interactions were found, *Fs* < 1.

Figure 1. Grand mean averaged ERPs waveforms elicited by neutral (black) and unpleasant adjectives (red) at selected electrode positions for the whole sample. Bottom, topographic voltage map for N100.

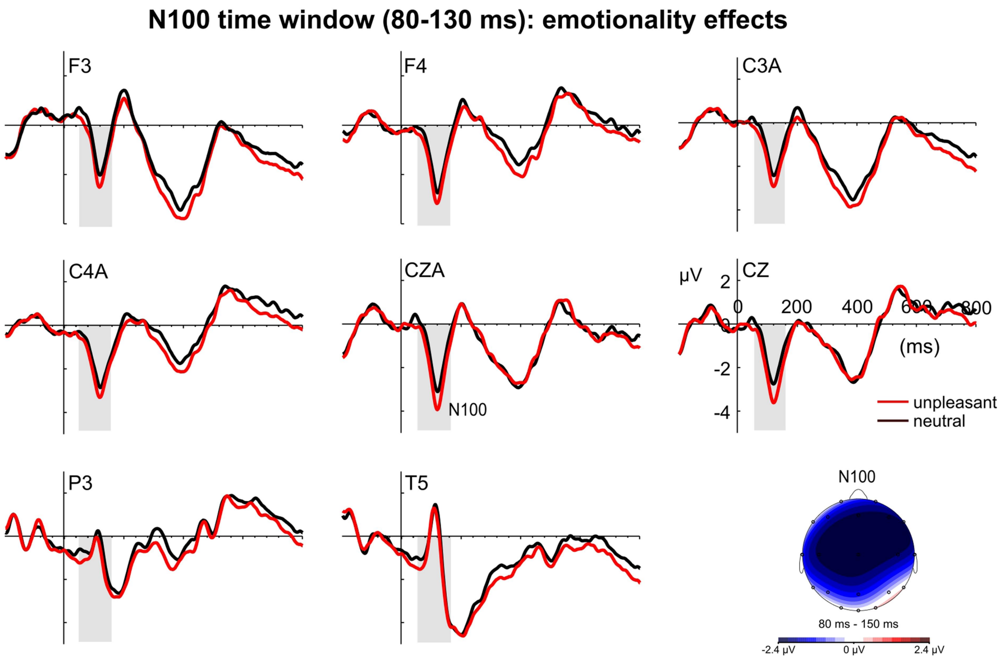


Table 4. *F*-statistics from the omnibus ANOVAs for the main time windows analysed.

	ERPs			Performance	
	80-130 ms	300-450 ms	550-750 ms	Hits	RTs
Gram. (1,55)	-	4.89**	4.73**	-	4.37**
Emo. (1,55)	3.84*	6.00**	-	-	-
ROI (3,165) /(4, 220)[a]	3.91***	41.13***	24.69**	NA	NA
Gram. × ROI (3,165) /(4, 220)	-	2.60*	16.35***	NA	NA
Emo. × ROI (3,165) /(4,220)	-	-	-	NA	NA
Gram. × Emo. (1,55)	-	5.72**	-	-	-
Gram. × Emo. × ROI (3,165) /(4,220)	-	-	-	NA	NA

Degrees of freedom are presented in parentheses. Gram. = Grammaticality; Emo. = Emotionality; NA = Non-applicable.

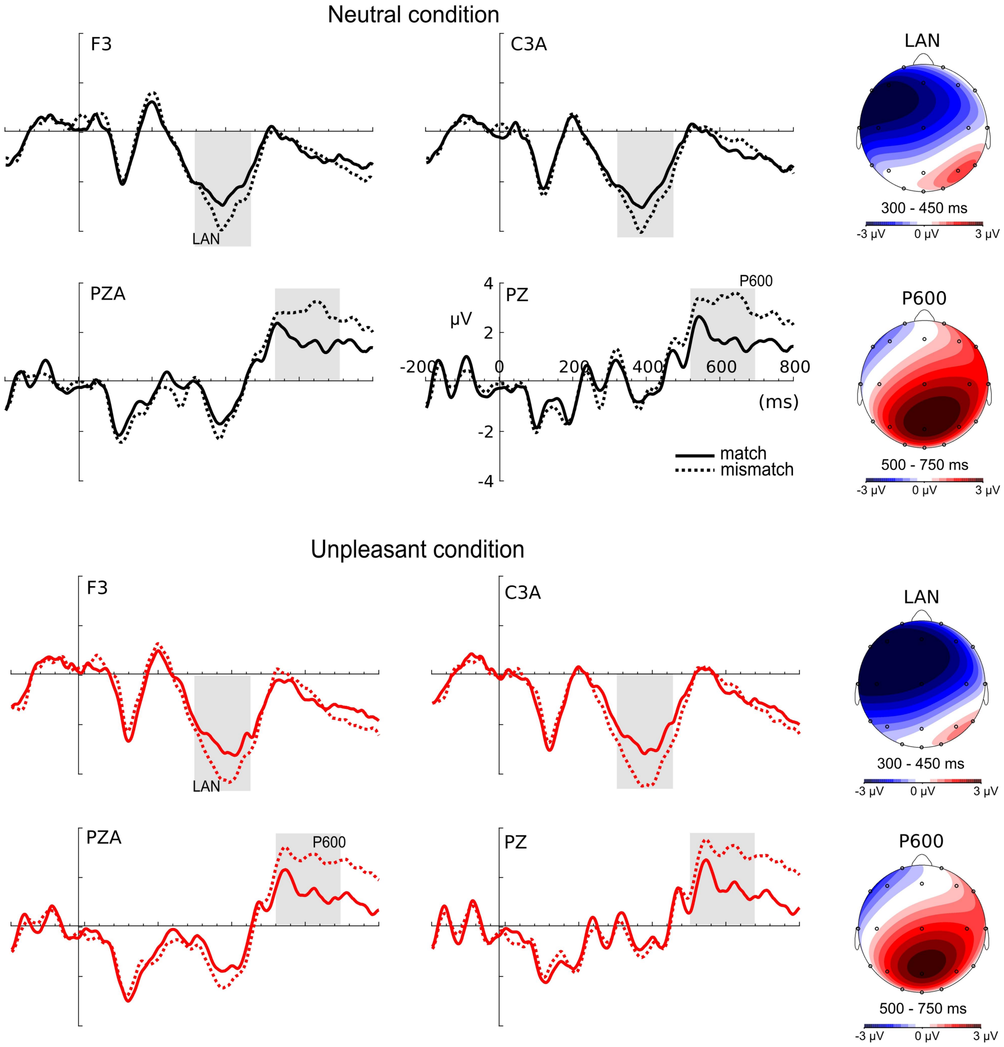
[a]. Degrees of freedom for the P600 time-window.

**p* = .05; ***p* < .05; ****p* < .001

LAN effects

In the time window between 300 and 450 ms, the omnibus ANOVA showed main effects of Grammaticality, Emotionality and ROI. We observed larger amplitudes in the mismatch condition (−1.12 µV) than in the match condition (−0.72 µV). Also, unpleasant adjectives elicited significantly larger amplitudes (−1.10 µV) than neutral ones (−0.74 µV). Regarding the ROI factor, enhanced amplitudes were found in the left anterior region in comparison to right anterior and posterior regions (p_s < .05). The Grammaticality × ROI interaction revealed that significantly higher amplitudes in the mismatch vs the match condition (the LAN effect) were only found in the left anterior region, $F(1,55) = 4.64$, $p = .01$, $\eta_p^2 = 0.11$, and the right anterior region, $F(1,55) = 6.22$, $p = .01$, $\eta_p^2 = 0.10$. Moreover, we found a significant interaction between Grammaticality and Emotionality in the RA region, $F(1,55) = 7.71$, $p = .007$, $\eta_p^2 = 0.12$), and a marginally significant interaction between these two factors in the LA region, $F(1,55) = 2.98$, $p = .08$, $\eta_p^2 = 0.05$, showing that the LAN effects only appeared in unpleasant adjectives ($p < .001$), whereas no statistical differences were observed between match and mismatch conditions for neutral adjectives ($p > .05$) (see Figure 2).

Figure 2. Grand mean averaged ERPs waveforms for match (solid line) and mismatch conditions (dashed line) evoked by neutral and unpleasant adjectives at several electrode positions for the whole sample (left). Right side, topographic voltage maps showing the LAN and P600 effects for both valence conditions.



P600 effects

In the 500-750 ms time window, the omnibus ANOVA showed main effects of Grammaticality and ROI, showing larger amplitudes in the mismatch condition (0.95 µV) than in the match condition (0.38 µV), the P600 effect, and enhanced amplitudes in posterior regions (RP, CP and LP) in comparison to right anterior and posterior regions. Moreover, an interaction between Grammaticality and ROI revealed that mismatch phrases elicited significantly higher amplitudes than match phrases only in the left posterior region, $F(1,55) = 8.26$, $p = .005$, $\eta_p^2 = 0.13$, the central posterior region, $F(1,55) = 17.95$, $p = .000$, $\eta_p^2 = 0.24$, and the right posterior region, $F(1,55) = 10.09$, $p = .002$, $\eta_p^2 = 0.15$. No other effects or interactions were found, $Fs < 1$ (see Figure 2).

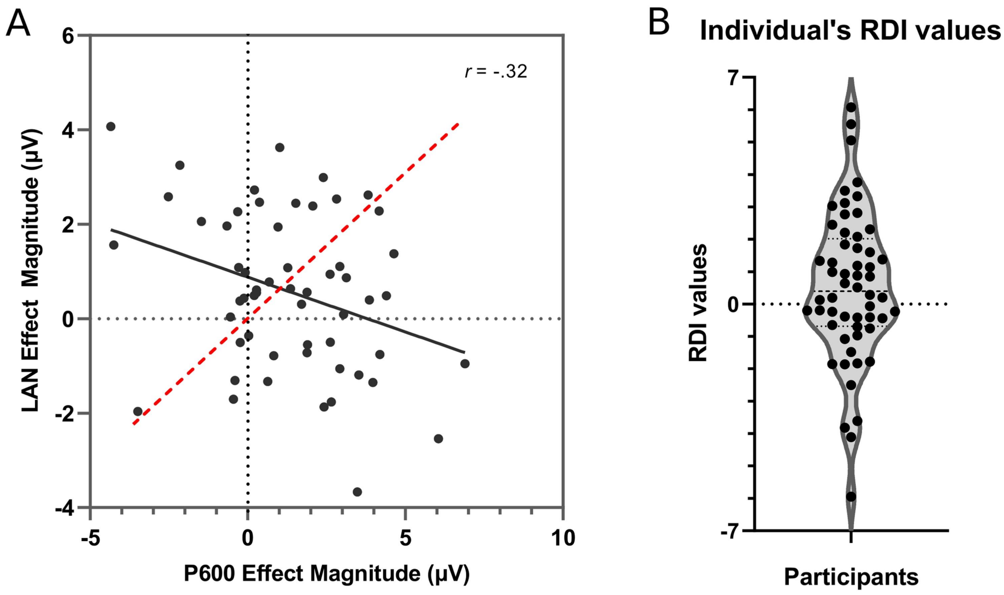
Analysis of individual differences

Given recent evidence indicating individual differences in morphosyntactic processing indexed by the LAN component (e.g. Tanner & Van Hell, 2014), the main objective of the current study was to examine whether individual differences in this component modulate the impact of emotion features during the processing of gender agreement, in an attempt to shed light on the discrepancies found in previous studies (e.g. Hinojosa et al., 2014 vs Fraga et al., 2017; Padrón et al., 2020). To analyse the participants' ERP profile, we calculated the individual size of LAN and P600 effects, in which LAN and P600 refer to mean amplitude from a left-anterior ROI [Fp1, F3 and C3A] and a centro-parietal ROI [CZ, PZa, and Pz], by subtracting the match minus the mismatch condition in the 300–450 time-window, and the mismatch minus the match condition in the 550–700 time-window, for LAN and P600 components, respectively. These effect magnitudes showed a significant negative correlation across participants ($r = -.32$, $p < .001$); that is, individuals who showed a higher P600 effect tended to show less LAN effects, and vice versa (see Figure 3A). Following the procedure used by Tanner and Van Hell (2014), we also calculated each individual's response dominance (the Response Dominance Index; RDI) by fitting the individual's least square distance from the equal effect size lines (dotted red line in Figure 3A) using perpendicular offsets (see formula below). This index measures the participant's relative predominance towards a negativity or a positivity regardless of magnitude; values near to zero mean relatively similar dominance of LAN and P600, while negative and positive values mean relative dominance of a negativity or positivity. In line with these authors' results, the current analysis also revealed that participants showed a continuous distribution between LAN-dominance, biphasic effects, and P600 dominance (see Figure 3B).

$$\eqalign{& {\rm RDI} = \cr& \displaystyle{{\left(P600mismatch\; -\; P600match \right) -\; \left(LANmatch-\; LANmismatch \right) } \over {\sqrt 2 }}}$$

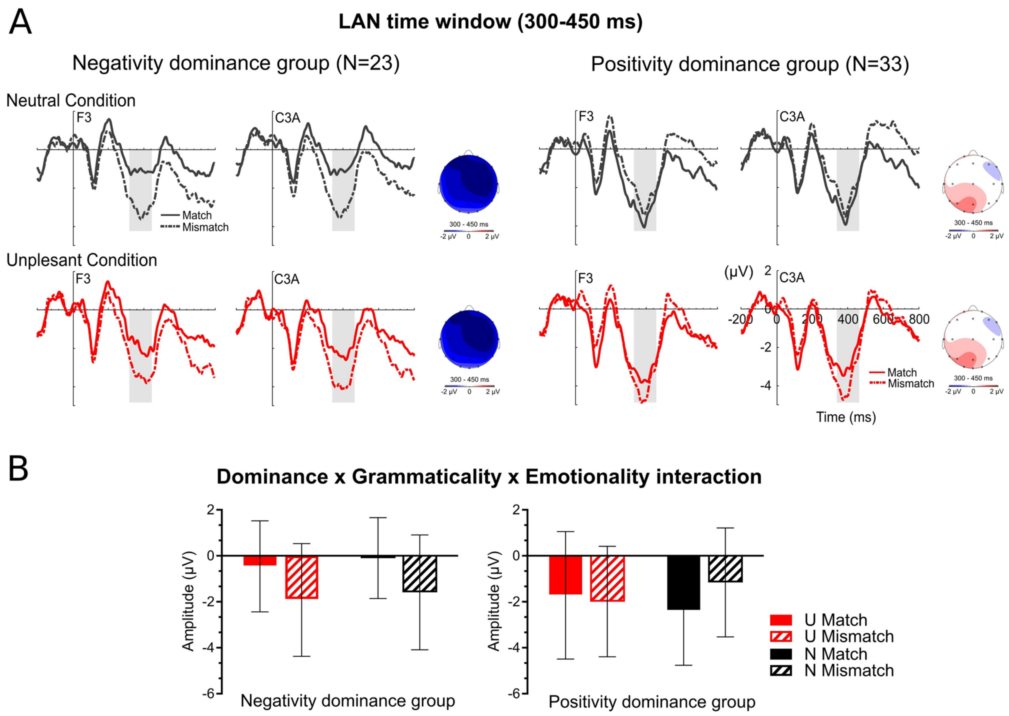
Figure 3. A, Scatterplot showing the distribution of LAN and P600 effect amplitudes across individuals averaged with the left anterior ROI (Fp1, F3 and C3A) and the centro-parietal ROI (CZ, PZA and PZ) for LAN and P600, respectively. Each dot represents a data from a single participant. The solid line indicates the best-fit line from the correlation analysis of participants' LAN and P600 effect magnitudes. The dashed line represents equal LAN and P600 magnitudes. Participants above/to the left of the dashed line have a positivity dominance pattern (more P600 effects); participants

below/to the right of the dashed line have a negativity dominance pattern (more LAN effects). B, Violin plot showing the distribution of RDI values across participants. More negative values represent a negativity dominance pattern while more positive values represent a positivity dominance pattern. Values closer to zero indicates a biphasic pattern (similar LAN and P600 effects).



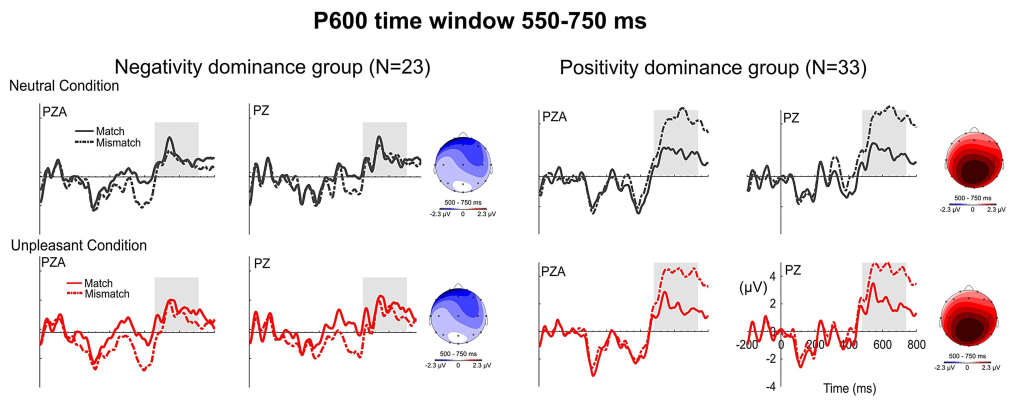
We then explored the averaged ERPs for those participants who presented a negativity profile (those above and to the left of the dotted red line in Figure 3A (N = 23 participants) and a positivity profile (those below and to the right of the dotted red line in Figure 3A (N =33 participants), to analyse the LAN and P600 effects for each dominance group.[2] Based on the results of the omnibus ANOVA for the LAN component, we focused on the anterior regions; thus, a 2 × 2 × 2 × 2 (Dominance profile, Grammaticality × Emotionality × ROI: LA and RA) repeated measures ANOVA was performed in the LAN time-window. This analysis revealed main effects of Grammaticality, $F(1,54) = 13.57$, $p = .001$, $\eta_p^2 = 0.20$, Emotionality, $F(1,54) = 5.70$, $p = .041$, $\eta_p^2 = 0.20$, and Region, $F(1,54) = 44.107$, $p = .00$, $\eta_p^2 = 0.46$. Moreover, we found a significant interaction between Dominance and Grammaticality, $F(1, 54) = 16.82$, $p = .001$, $\eta_p^2 = 0.24$, that showed that only the participants with a negativity dominance pattern exhibited the LAN effects (see Figure 4A). Critically, we also obtained a triple interaction between Dominance, Grammaticality, and Emotionality, $F(1, 54) = 5.58$, $p = .02$, $\eta_p^2 = 0.24$. We then proceeded with two analyses for each dominance profile. Results revealed that the negativity dominance group only showed a main Grammaticality effect, $F(1, 22) = 23.09$, $p = .000$, $\eta_p^2 = 0.30$, with similar LAN effects in the neutral and unpleasant conditions ($p_s > .05$) (see Figure 4A, left). On the contrary, the positivity dominance group showed a main effect of Emotionality, $F(1, 32) = 5.14$, $p = .03$, $\eta_p^2 = 0.13$, with higher amplitudes in the unpleasant (−2.06 µV) than in the neutral (−1.58 µV) condition, as well as a Grammaticality × Emotionality interaction, $F(1, 32) = 14.10$, $p = .000$, $\eta_p^2 = 0.30$. *Post hoc* comparisons revealed that, quite surprisingly, this group showed significantly higher amplitudes in match than in mismatch trials, but only in the neutral condition ($p = .03$) (see Figure 4B).

Figure 4. A, Grand mean averaged ERPs waveforms for match (solid line) and mismatch conditions (dashed line) at F3 and C3A electrodes as a function of neutral (black) and unpleasant (red) conditions for the negativity dominance group (left) and the positivity dominance group (right) in the LAN time window. Right side, topographic voltage maps showing the difference between match and mismatch conditions for the two response dominance patterns. B, Bar chat reflecting mean ERP amplitudes in the anterior ROIs (LA and RA) for match and mismatch conditions as a function of neutral (black) and unpleasant (red) conditions for the negativity dominance group (left) and the positivity dominance group (right). Error bars show the standard error of the mean (SEM).



For the P600 component, and based on the results of the omnibus ANOVA, we focused on the posterior sites; thus, a 2 × 2 × 2 × 3 (Dominance profile, Grammaticality × Emotionality × ROI: LP, CP, RP) repeated measures ANOVA was performed in the P600 time-window. The analysis revealed main effects of Dominance, $F(1,54) = 6.54$, $p = .013$, $\eta _p^2 = 0.11$, and Grammaticality, $F(1,54) = 12.29$, $p = .000$, $\eta _p^2 = 0.18$, ROI, $F(2,108) = 30.04$, $p = .000$, $\eta _p^2 = 0.35$. The participants obtained higher P600 amplitudes in the mismatch condition (1.28 µV) than in the match condition (0.54 µV), and these effects were more evident at central-parietal scalp sites. Also, the positivity dominance group showed higher P600 amplitudes (1.75 µV) than the negativity dominance group (0.08 µV). Moreover, significant interactions between Dominance and Grammaticality, $F(1,54) = 33.15$, $p = .000$, $\eta _p^2 = 0.38$, and between Dominance, Grammaticality and ROI, $F(2,108) = 7.05$, $p = .000$, $\eta _p^2 = 0.12$, were also found. The analyses for each dominance profile revealed that the positivity dominance group showed main effects of Grammaticality, $F(1, 32) = 54.13$, $p = .000$, $\eta _p^2 = 0.69$, and ROI, $F(1, 22) = 23.09$, $p = .000$, $\eta _p^2 = 0.30$, while the negativity dominance group did not show any effects, $Fs < 1$. Overall, this analysis revealed that only the participants with a positivity dominance pattern showed the classical P600 effect (see Figure 5).

Figure 5. Grand mean averaged ERPs waveforms for match (solid line) and mismatch conditions (dashed line) at PZA and PZ electrodes as a function of neutral (black) and unpleasant (red) conditions for the negativity dominance group (left) and the positivity dominance group (right) in the P600 time window. Right side, topographic voltage maps showing the difference between match and mismatch conditions for the two response dominance patterns.

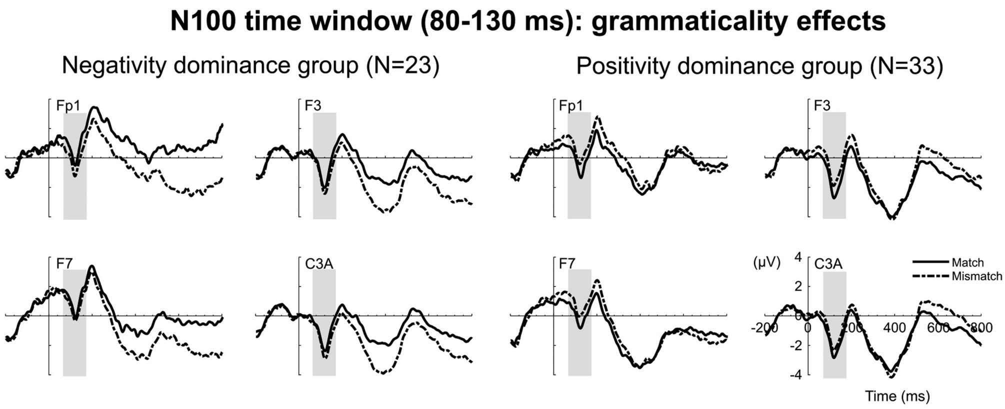


In sum, the present results, in line with Tanner ~~et al.~~& Van Hell (2014) and Tanner **[Q5]**;~~(~~2019), showed that participants revealed a continuous distribution between LAN-dominance, biphasic effects, and P600 dominance; thus, grammatically incorrect NPs elicited more LAN effects in some participants (34%), a biphasic LAN-P600 effect in others (14%), and more P600 effects in the remaining participants (52%). Notably, we found an interaction between Grammaticality and Emotionality in the LAN time window *only* in the individuals with a positivity dominance profile. However, this interaction did not derive from an increase or decrease of the LAN amplitude as a function of emotionality; rather, these participants showed an inverse pattern of grammaticality effects in neutral adjectives.

In light of these results, we also decided to perform the analyses in early time windows (80-130 ms and 200-300 ms) in order to explore possible differences based on the dominance pattern. A 2 × 2 × 2 × 4 (Dominance × Grammaticality × Emotionality × ROI) repeated measures ANOVA for the N100 time window showed main effects of ROI, $F(3,162) = 4.02$, $p = .000$, $\eta _p^2 = 0.06$, and Emotionality, $F(1,54) = 3.29$, $p = .07$, $\eta _p^2 = 0.06$. Interestingly, we found a Dominance × Grammaticality × ROI interaction, $F(3,162) = 4.02$, $p = .008$, $\eta _p^2 = 0.07$. Further analyses in each region revealed a Dominance × Grammaticality interaction only in the LA region, $F(1,54) = 11.31$, $p = .001$, $\eta _p^2 = 0.17$, indicating that the positivity dominance group showed enhanced N100 amplitudes in the match condition (−1.13 µV) in comparison to the mismatch condition (−0.51 µV) ($p = .04$), while the negativity dominance group did not show significant differences between match and mismatch conditions ($p > .05$; see Figure 6). As for the EPN time window, the

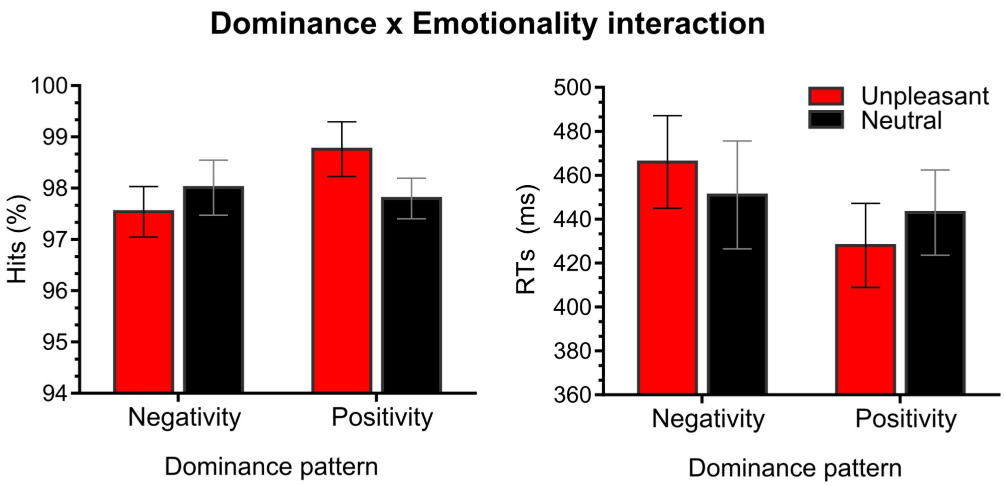
ANOVA did not reveal any significant main effects or interactions, all *Fs* (1, 54) <1.

Figure 6. Grand mean averaged ERPs waveforms for match (solid line) and mismatch conditions (dashed line) at left anterior sites for the negativity dominance group (left) and the positivity dominance group (right) in the N100 time window.



Moreover, we also analysed the behavioural data and subjective ratings in each dominance profile. Regarding the performance, a 2 × 2 × 2 (Dominance × Grammaticality × Emotionality) repeated measures ANOVAs revealed a significant interaction between Dominance and Emotionality for RTs, $F(1,54) = 4.74$, $p = .03$, $\eta_p^2 = 0.08$, and a marginally significant interaction for hits, $F(1,54) = 3.45$, $p = .06$, $\eta_p^2 = 0.06$. These effects indicated that the negativity dominance group showed a higher percentage of hits (98%) and lower RTs (451 ms) for the neutral condition than for the unpleasant condition (97% and 465 ms, respectively), while the positivity dominance group showed the opposite pattern, with higher percentage of hits (99%) and lower RTs (428 ms) for the unpleasant in comparison to the neutral condition (98% and 443 ms, respectively). However, *post-hoc* comparisons were not statistically significant, probably due to high variability across participants (see Figure 7).

Figure 7. Percentage of correct responses (left) and mean RTs (right) for unpleasant (red) and neutral (black) conditions as a function of the brain pattern. Error bars show the standard error of the mean (SEM).



The analyses for the subjective ratings on valence, arousal and plausibility of the NPs showed neither a significant effect of Dominance nor significant interactions between Dominance and Gender or Dominance and Emotionality; $Fs(1,53) < 2$.

Discussion

In the present study we analysed the neural correlates of the relationship between morphosyntactic processing and emotionality in a sample of participants that performed a grammatical judgment task. Previous evidence has shown divergent results, particularly in the LAN time window. For this reason, we first analysed the behavioural and ERP effects for the whole sample, and subsequently examined the brain dominance pattern to clarify the role of individual differences in the effects of emotion on morphosyntactic processing. For the whole sample, participants showed a high level of performance in terms of both accuracy and speed measures. Lower RTs were observed in ungrammatical trials than in grammatical trials, indicating that gender agreement errors were easier to process than their grammatical counterparts.

Regarding the ERPs, our results first revealed an early emotionality effect. Unpleasant adjectives, relative to neutral adjectives, elicited enhanced amplitudes in the N100 component ($p = .05$). Of note, N100 effects have not previously been reported in studies investigating emotion effects on the processing of morphosyntactic cues (Fraga et al., 2017; Hinojosa et al., 2014; Jiménez-Ortega et al., 2017; Martín-Loeches et al., 2012; Padrón et al., 2020). Nonetheless, similar N100 modulations have been reported for emotional words that were unexpected given the preceding semantic context (León et al., 2010; Moreno & Rivera, 2014) or for isolated emotional words (Kissler & Herbert, 2013; Scott et al., 2009), and have been interpreted as an indicator of the preferential capture of attention by negative content. Therefore, our data seem to suggest very early access (around 100 ms) to emotional information in words, this taking place before the processing of morphosyntactic features based on gender agreement.

Second, results in the LAN time window showed enhanced amplitudes in mismatch relative to match stimuli, as well as in unpleasant adjectives compared to neutral ones. Importantly, a significant interaction between grammaticality and emotionality showed that a LAN amplitude enhancement was only observed for unpleasant words. The absence of an effect which is thought to reflect the difficulty of processing gender errors in neutral words is unexpected and difficult to interpret and, more importantly, does not align with any of the previous studies. Thus, while Fraga and her colleagues (2015, 2017, ~~p.~~ 2020) systematically found a lack of interaction between grammaticality and emotionality, since neither positive nor negative words affected the enhanced LAN amplitudes evoked by the presence of gender violations, Martín-Loeches et al. (2012) obtained larger LAN amplitudes for negative words than for neutral words, yet the mismatch effect was also present in this last condition. On the contrary, in Hinojosa et al. (2014) a lack of the LAN effect was found for negative rather than for neutral words. Briefly, in the presence of morphosyntactic violations in negative words compared to neutral ones, Martín-Loeches et al. found an augmented LAN, Hinojosa et al. found no LAN effects, Fraga et al. found similar LAN effects in unpleasant and neutral conditions, and finally, in the present study we obtained the classical LAN effect only in the unpleasant condition, while it was absent in the neutral one. However, the analysis by groups with a different brain pattern can shed some light on these inconsistent results (see below).

Third, our results showed that P600 amplitudes were significantly larger in the presence of gender agreement violations, an effect that has been systematically obtained across all previous studies. Moreover, both emotionality effects and interactive effects between grammaticality and emotionality were also absent in this time window. Thus, negative valence does not affect late reanalysis processes associated with the presence of gender agreement errors.

Summarising the results for the whole sample, they show: a) an early (marginal) effect of emotionality; b) both grammaticality and emotionality effects, as well as a significant interaction between morphosyntactic and affective processing, in the LAN time window; and c) a grammaticality effect in the P600 component. This would reveal that emotionality is temporally prioritised in the brain, while grammaticality is analysed later. More importantly, the interaction between grammaticality and emotionality that emerged in the intermediate (LAN) time window goes against the idea that the establishment of gender agreement takes place in an autonomous, encapsulated way, as proposed in Fodor's theory of modularity (1983). Rather, these results would support previous evidence of interactive effects between morphosyntactic and affective processing (e.g. Martín-Loeches et al., 2012; Hinojosa et al., 2014). Interestingly, Hinojosa et al.'s study and the present one are very similar; both used a broad sample of participants, the same type of materials (NPs with negative versus neutral words), and a similar procedure. However, as already indicated, Hinojosa et al. found a lack of the typical LAN grammaticality effect only in unpleasant words, while we obtained it only in neutral words. Of note, the only difference between Hinojosa et al.'s study and the present one is the level of arousal of the emotional words selected (see also Fraga, 2020). Future studies should try to show whether the arousal level may also clarify these discrepant results, as it is possible that highly arousing negative words are easier to process than moderately arousing ones, in line with the biological relevance of threatening stimuli (Fraga et al., 2018; Hinojosa et al., 2020; Vieitez, 2019), thus facilitating the detection of agreement errors.

Apart from the arousal dimension, we suggested the possibility that individual differences in morphosyntactic processing may account for these inconsistent results, as well as for the LAN effects obtained in our own study when considering the whole sample. With this aim, we used Tanner and Van Hell's (2014) procedure and calculated the RDI. In line with these authors' previous results, our analyses revealed a total of three neural patterns, in such a way that one group of participants only showed LAN effects (the negativity dominance group), another group showed both LAN and P600 effects (the biphasic pattern group), and a further group showed only P600 effects (the positivity dominance group). Moreover, regarding the critical comparison between correct and incorrect trials in the LAN component, while the negativity profile group showed higher amplitudes in both neutral and unpleasant mismatch items, the positivity profile group, unexpectedly, showed higher amplitudes in neutral match items than in neutral mismatch items. A number of issues might usefully be noted here in relation to the by-group results. First, there are indeed individual differences in morphosyntactic processing, so the classic biphasic LAN/P600 effects may be the exception rather than the rule. Second, in the present study the interaction between Grammaticality and Emotionality in the LAN time window was exclusively due to the group of participants showing a positivity dominance pattern. Third, we also found differences between the two groups of participants in the earliest window (around 100 ms), although they were related to grammaticality rather than to emotionality. Thus, while both groups showed a marginally significant early effect of emotionality, which would confirm the priority of affective information in the brain, the positivity dominance group also showed an amplitude enhancement in this component in match trials when compared to mismatch trials. We believe that such an early grammaticality effect, with match trials appearing to capture more attention than those with the morphosyntactic violation, might indicate that at least these participants were processing grammaticality (at the left anterior region) and emotionality (distributed across regions) in parallel. To our knowledge, there is very little evidence currently available of this early effect associated with grammaticality factors. Leikin and Breznitz (1999) obtained a similar negativity with native Hebrew speakers, although in that study there were no morphosyntactic violations, but rather normal word strings. The authors found higher N100 amplitudes in the main parts of the sentences (predicates compared with subjects and these compared with objects or prepositions) that would arise as a result of the process of searching and identifying the main grammatical roles in the sentence, these having captured the participants' attention. Importantly, this would be evidence of an encapsulated first stage in reading in which the parser uses syntactic information to build the grammatical structure, as proposed in classical models of autonomous sentence processing (e.g. Frazier, 1987). In a more recent study Foucart and Frenck-Mestre (2011) reported a N100 for gender agreement errors in noun–adjective pairs, although this effect only emerged in a group of German L2 learners of French and not in native French speakers. Clearly, more research is needed to elucidate the extent and reliability of this effect (for early grammaticality effects in auditory experiments, see, for instance, Hasting & Kotz, 2008 and Pulvermüller & Shtyrov, 2003). Of note, the early effects obtained in our study are consistent with those in the LAN time window. Thus, the by-group analyses reveal two different scenarios. On the one hand, in the negativity dominance group the emotional words captured the participants' attention very early, thus evoking higher N100 amplitudes in unpleasant words than in neutral ones; these participants then processed grammaticality (the adjective agrees or does not agree in gender with the preceding noun) in an encapsulated way, thus showing the classical LAN effect; and finally, they did not show any further reanalysis effects or affective effects in the P600 window. In sum, this group seems to have temporarily prioritised emotionality, and not to have processed grammar and emotionality in parallel in any time window. Hence, these participants did not show any kind of interaction between these two factors along the time course or in performance, yet they appeared to perform slightly worse in unpleasant trials. On the other hand, the positivity dominance group first showed very early grammaticality and emotionality effects (paying more attention to correct and unpleasant stimuli, respectively) that were independent from each other. In the subsequent LAN window, we observed these same main effects, as well as an interaction between emotionality and grammaticality. On these lines, we found enhanced amplitudes for match relative to mismatch neutral trials, whereas no differences were found for unpleasant trials. At the moment we can only speculate about a possible effect of the concurrent processing of grammaticality and emotionality that resulted in an inverted LAN effect for neutral words. Nonetheless, the interaction between emotion and grammar is interesting and suggests a processing advantage during the early detection of morphosyntactic errors in the unpleasant condition for the group of participants showing positivity dominance, since no LAN differences were observed between correct and incorrect phrases (see also Hinojosa et al., 2014 for a similar finding). Finally, the positivity dominance group showed the classical P600 grammaticality effect, and this group also performed the task efficiently, although, unlike the other group, they appeared to perform better in the emotional than the neutral conditions. It is noteworthy that, although an interaction between grammaticality and emotionality did emerge in the 400 ms windows in this group, we cannot firmly conclude that, in terms of the classical LAN effect, the emotionality of the adjectives influenced the processing of agreement errors. Likewise, we may also tentatively suggest that, if there had been an effect of emotionality on performance, it would go in the opposite direction in the two participant groups.

Conclusions

The results of the present study confirm that there are individual differences in morphosyntactic processing at the neurophysiological levels. Specifically, different brain patterns were found when participants performed a grammaticality judgement task. Thus, in the presence of gender agreement errors, some people tend to show a negativity dominance pattern characterised by higher amplitudes in the LAN component, while others tend to show a positivity dominance pattern reflected in higher amplitudes in P600. These effects confirm previous results (Tanner, 2015, 2019; Tanner & Van Hell, 2014) and do not seem to be fully explained by the presence of emotional words. In a recent paper, Tanner (2019) analysed other factors, such as language experience and verbal working memory capacity in native English speakers, without clarifying which “latent variable” lies behind individual differences in morphosyntactic processing (but see, for example, Vos et al., 2001, for LAN effects only obtained in participants with a high memory span).

The present study also reveals that, when it comes to the possible interaction between morphosyntactic and affective processing, individual differences play an important role, not only in the classical time windows of LAN and P600, but also at earlier stages. Thus, we found a very early effect of grammaticality in one group of participants which was comparable to the more expected effect of emotionality found in the two groups. Therefore, besides confirming the privileged status of affective information in the brain (e.g. Bayer et al., 2012; Hofmann et al., 2009; Kissler & Herbert, 2013; Kousta et al., 2009; Kuperman et al., 2014), our results would also seem to support Fodor’s hypothesis (1983) on the temporal priority and encapsulation of syntactic processing, at least in some individuals and tasks. However, we are cautious about interpreting the early grammaticality effect obtained here, as this effect would need to be further replicated, and we should also bear in mind that, as we have seen, it might not be universal. Emotionality aside, the present results point to different processing strategies in different individuals when they are asked to perform the grammaticality judgement task. Why these differences occur, and what factors are behind them, remain unanswered questions.

Future research should take into account the neural effects along the entire time course, from the earliest to the latest windows, in order to better characterise morphosyntactic processing, and to establish whether or not an interaction between grammatical and affective information occurs during verbal processing depending on the individual’s brain pattern. Ultimately, the question of whether there is an interaction between grammaticality and emotionality, in the sense of either an increase or a decrease in the amplitude of the LAN classically associated with the presence of morphosyntactic violations, remains open. However, taken together our results suggest that the discrepancy with findings in previous studies might be explained in part by underexplored individual differences. Importantly, these findings also open new and exciting questions about the interplay between language and emotion, the answers to which will require further investigation.

Notes

1. The latency of the LAN effects in the study by Jiménez et al. is rather delayed. Nonetheless, the anterior distribution and the polarity of the effects led the authors of that study to interpret their effects in terms of a LAN component (they noted that effects at posterior electrodes could also reflect an earlier onset on the P600 that would peak later).

2. Although participants showed a continuous distribution between LAN-dominance, biphasic effects, and P600 dominance, we kept the original procedure of Tanner et al., in which each participant was assigned to one of the two dominance groups (negativity or positivity), to perform the statistical analyses and facilitate comparisons across studies. However, we also performed the statistical analyses for the LAN and P600 components without those participants who belonged to the biphasic group (that is, those who obtained RDI values between ± 0.20; N = 8 participants; and who were also very close to the red-dashed line, see Figure 3A), thus reducing the number of participants to 19 in the negativity dominance group, and 29 in the positivity dominance group. The results of the ANOVAs for each of the time windows remained unchanged. Furthermore, despite being a very small number of participants, we also performed the statistical analyses in the LAN and P600 windows for the biphasic group on its own. The results of both ANOVAs revealed only a main effect of grammaticality for LAN, $F(1,7) = 7.62$, $p = .02$, $\eta _p^2 = 0.51$, and P600, $F(1,7) = 7.78$, $p = .02$, $\eta _p^2 = 0.52$, without any further interactions, $Fs(1,7) < 1$, confirming that these participants showed the grammaticality effect in both time windows.

Acknowledgments

~~The present study was supported by the Ministerio de Economía y Competitividad (MINECO) of Spain (PSI2015-65116-P and PID2019-110583GB-I00), Xunta de Galicia (ED431B 2019/2020), Ministerio de Ciencia, Innovación y Universidades of Spain (PGC2018-098558-B-I00), and the Comunidad de Madrid (H2019/HUM-5705).~~ We thank two anonymous reviewers for their comments and suggestions in response to a previous version of this study.

Disclosure statement

No potential conflict of interest was reported by the author(s **[Q6]**).

ORCID

I. Fraga http://orcid.org/0000-0001-9346-6560

J. A. Hinojosa http://orcid.org/0000-0002-7482-9503

References

Barber, H., & Carreiras, M. (2005). Grammatical gender and number agreement in Spanish: An ERP comparison. *Journal of Cognitive Neuroscience*, *17*(1), 137–153. https://doi.org/10.1162/0898929052880101

Bayer, M., Sommer, W., & Schacht, A. (2012). P1 and beyond: Functional separation of multiple emotion effects in word recognition. *Psychophysiology*, *49*(7), 959–969. https://doi.org/10.1111/j.1469-8986.2012.01381.x

Bernat, E., Bunce, S., & Shevrin, H. (2001). Event-related brain potentials differentiate positive and negative mood adjectives during both supraliminal and subliminal visual processing. *International Journal of Psychophysiology*, *42*(1), 11–34. http://www.ncbi.nlm.nih.gov/pubmed/11451477 https://doi.org/10.1016/S0167-8760(01)00133-7

Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: The Self-assessment manikin and the semantic differential. *Journal of Behavior Therapy and Experimental Psychiatry*, *25*(1), 49–59. https://doi.org/10.1016/0005-7916(94)90063-9

Caffarra, S., Janssen, N., & Barber, H. A. (2014). Two sides of gender: ERP evidence for the presence of two routes during gender agreement processing. *Neuropsychologia*, *63*, 124–134. https://doi.org/10.1016/j.neuropsychologia.2014.08.016

Caffarra, S., Mendoza, M., & Davidson, D. (2019). Is the LAN effect in morphosyntactic processing an ERP artifact? *Brain and Language*, *191*, 9–16. https://doi.org/10.1016/j.bandl.2019.01.003

Cao, Y., Yang, Y., & Wang, L. (2019). Concurrent emotional response and semantic unification: An event-related potential study. *Cognitive, Affective, & Behavioral Neuroscience*, *19*(1), 154–164. https://doi.org/10.3758/s13415-018-00652-5

Citron, F. M. (2012). Neural correlates of written emotion word processing: A review of recent electrophysiological and hemodynamic neuroimaging studies. *Brain and Language*, *122*(3), 211–226. https://doi.org/10.1016/j.bandl.2011.12.007

Corbett, G. C. (2006). *Agreement*. Cambridge University Press.

Davis, C. J., & Perea, M. (2005). Buscapalabras: A program for deriving orthographic and phonological neighborhood statistics and other psycholinguistic indices in Spanish. *Behavior Research Methods*, *37*(4), 665–671. http://www.ncbi.nlm.nih.gov/pubmed/16629300 https://doi.org/10.3758/BF03192738

Delaney-Busch, N., & Kuperberg, G. (2013). Friendly drug-dealers and terrifying puppies: Affective primacy can attenuate the N400 effect in emotional discourse contexts. *Cognitive, Affective, & Behavioral Neuroscience*, *13*(3), 473–490. https://doi.org/10.3758/s13415-013-0159-5

Díaz-Lago, M., Fraga, I., & Acuña-Fariña, C. (2015). Time course of gender agreement violations containing emotional words. *Journal of Neurolinguistics*, *36*, 79–93. https://doi.org/10.1016/j.jneuroling.2015.07.001

Ding, J., Wang, L., & Yang, Y. (2020). The influence of emotional words on predictive processing during sentence comprehension. *Language, Cognition and Neuroscience*, *35*(2), 151–162. https://doi.org/10.1080/23273798.2019.1628283

Fodor, J. (1983). *The modularity of mind*. MIT.

Foucart, A., & Frenck-Mestre, C. (2011). Grammatical gender processing in L2: Electrophysiological evidence of the effect of L1 - L2 syntactic similarity. *Bilingualism, Language and Cognition*, *14*(3), 379–399. https://doi.org/10.1017/S136672891000012X

Fraga, I. (2020). Two brains in one mind or … why we should not take for granted the interaction between morphosyntactic and affective processing: A commentary on Hinojosa, Moreno, and Ferré (2019). *Language, Cognition and Neuroscience*, 858–861. https://doi.org/10.1080/23273798.2019.1645867

Fraga, I., Padrón, I., Acuña-Fariña, C., & Díaz-Lago, M. (2017). Processing gender agreement and word emotionality: New electrophysiological and behavioural evidence. *Journal of Neurolinguistics*, *44*, 203–222. https://doi.org/10.1016/j.jneuroling.2017.06.002

Fraga, I., Padrón, I., Ferré, P., & Perea, M. (2018, July). *Recognizing negative words in a lexical decision task: The negligible effect of arousal*. First Joint Congress of the SEPEX, SEPNECA and AIP experimental. XII Congress of the Sociedad Española de Psicología Experimental (SEPEX), Madrid, Spain.

Frazier, L. (1987). Sentence processing: A tutorial review. In **M. Coltheart** (Ed.), *Attention and performance. XII: The psychology of reading* (pp. 559–586). Erlbaum.

Gratton, G., Coles, M. G., & Donchin, E. (1983). A new method for off-line removal of ocular artifact. *Electroencephalography & Clinical Neurophysiology*, *55*(4), 468–484. https://doi.org/10.1016/0013-4694(83)90135-9

Hagoort, P. (2005). On broca, brain, and binding: A new framework. *Trends in Cognitive Sciences*, *9*(9), 416–423. https://doi.org/10.1016/j.tics.2005.07.004

Hasting, A., & Kotz, S. (2008). Speeding up syntax: On the relative timing and automaticity of local phrase structure and morphosyntactic processing as reflected in eventrelated brain potentials. *Journal of Cognitive Neuroscience*, *20*(7), 1207–1219. https://doi.org/10.1162/jocn.2008.20083

Herbert, C., Junghofer, M., & Kissler, J. (2008). Event related potentials to emotional adjectives during reading. *Psychophysiology*, *45*(3), 487–498. https://doi.org/10.1111/j.1469-8986.2007.00638.x

Hinojosa, J. A., Albert, J., Fernández-Folgueiras, U., Santaniello, G., López-Bachiller, C., Sebastian, M., Sánchez-Carmona, A. J., & Pozo, M. A. (2014). Effects of negative content on the processing of gender information: An event-related potential study. *Cognitive, Affective, & Behavioral Neuroscience*, *14*(4), 1286–1299. https://doi.org/10.3758/s13415-014-0291-x

Hinojosa, J. A., Martín-Loeches, M., Casado, P., Muñoz, F., & Rubia, F. (2003). Similarities and differences between phrase structure and morphosyntactic violations in spanish: An event-related potentials study. *Language and Cognitive Processes*, *18*(2), 113–142. https://doi.org/10.1080/01690960143000489

Hinojosa, J. A., Moreno, E. M., & Ferré, P. (2020). Affective neurolinguistics: Towards a framework for reconciling language and emotion. *Language, Cognition and Neuroscience*, 813–839. https://doi.org/10.1080/23273798.2019.1620957

Hofmann, M. J., Kuchinke, L., Tamm, S., Vo, M. L., & Jacobs, A. M. (2009). Affective processing within 1/10th of a second: High arousal is necessary for early facilitative processing of negative but not positive words. *Cognitive, Affective, & Behavioral Neuroscience*, *9*(4), 389–397. https://doi.org/10.3758/9.4.389

Jiménez-Ortega, L., Espuny, J., de Tejada, P. H., Vargas-Rivero, C., & Martín-Loeches, M. (2017). Subliminal emotional words impact syntactic processing: Evidence from performance and event-related brain potentials. *Frontiers in Human Neuroscience*, *11*, 192. https://doi.org/10.3389/fnhum.2017.00192

Kanske, P., & Kotz, A. (2007). Concreteness in emotional words: ERP evidence from a hemifield study. *Brain Research*, *1148*, 138–148. https://doi.org/10.1016/j.brainres.2007.02.044

Kissler, J., Assadollahi, R., & Herbert, C. (2006). Emotional and semantic networks in visual word processing: Insights from ERP studies. *Progress in Brain Research*, *156*, 147–183. https://doi.org/10.1016/S0079-6123(06)56008-X

Kissler, J., & Herbert, C. (2013). Emotion, etmnooi, or emitoon?–Faster lexical access to emotional than to neutral words during reading. *Biological Psychology*, *92*(3), 464–479. https://doi.org/10.1016/j.biopsycho.2012.09.004

Kousta, S. T., Vinson, D. P., & Vigliocco, G. (2009). Emotion words, regardless of polarity, have a processing advantage over neutral words. *Cognition*, *112*(3), 473–481. https://doi.org/10.1016/j.cognition.2009.06.007

Kuperberg, G. R. (2007). Neural mechanisms of language comprehension: Challenges to syntax. *Brain Research*, *1146*, 23–49. https://doi.org/10.1016/j.brainres.2006.12.063

Kuperman, V., Estes, Z., Brysbaert, M., & Warriner, A. B. (2014). Emotion and language: Valence and arousal affect word recognition. *Journal of Experimental Psychology: General*, *143*(3), 1065–1081. https://doi.org/10.1037/a0035669

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1990). Emotion, attention, and the startle reflex. *Psychological Review*, *97*(3), 377–395. https://doi.org/10.1037/0033-295X.97.3.377

Leikin, M., & Breznitz, Z. (1999). Syntactic processing of Hebrew sentences: ERP measures. *Genetic, Social, and General Psychology Monographs*, *2*, 173–191 **[Q7]**.**[Q8]**

León, I., Díaz, J. M., de Vega, M., & Hernández, J. A. (2010). Discourse-based emotional consistency modulates early and middle components of event-related potentials. *Emotion*, *10*(6), 863–873. https://doi.org/10.1037/a0019983

Martín-Loeches, M., Fernández, A., Schacht, A., Sommer, W., Casado, P., Jiménez-Ortega, L., & Fondevila, S. (2012). The influence of emotional words on sentence processing: Electrophysiological and behavioral evidence. *Neuropsychologia*, *50*(14), 3262–3272. https://doi.org/10.1016/j.neuropsychologia.2012.09.010

Mendez-Bertolo, C., Pozo, M. A., & Hinojosa, J. A. (2011). Word frequency modulates the processing of emotional words: Convergent behavioral and electrophysiological data. *Neuroscience Letters*, *494*(3), 250–254. https://doi.org/10.1016/j.neulet.2011.03.026

Molinaro, N. (2020). "Words and emotions in sentence context": a commentary on Hinojosa, Moreno and Ferré (2019). *Language, Cognition and Neuroscience*, 862–864. https://doi.org/10.1080/23273798.2019.1647346

Molinaro, N., Barber, H. A., & Carreiras, M. (2011). Grammatical agreement processing in reading: ERP findings and future directions. *Cortex*, *47*(8), 908–930. https://doi.org/10.1016/j.cortex.2011.02.019

Moreno, E. M., & Rivera, I. C. (2014). Setbacks, pleasant surprises and the simply unexpected: Brainwave responses in a language comprehension task. *Social Cognitive and Affective Neuroscience*, *9*(7), 991–999. https://doi.org/10.1093/scan/nst066

Nakic, M., Smith, B. W., Busis, S., Vythilingam, M., & Blair, R. J. R. (2006). The impact of affect and frequency on lexical decision: The role of the amygdala and inferior frontal cortex. *Neuroimage*, *31*(4), 1752–1761. https://doi.org/10.1016/j.neuroimage.2006.02.022

Oldfield, R. C. (1971). The assessment and analysis of handedness: The Edinburgh inventory. *Neuropsychologia*, *9*(1), 97–113. http://www.ncbi.nlm.nih.gov/pubmed/5146491 https://doi.org/10.1016/0028-3932(71)90067-4

Osterhout, L., & Mobley, L. A. (1995). Event-related brain potentials elicited by failure to agree. *Journal of Memory and Language*, *34*(6), 739–773. https://doi.org/10.1006/jmla.1995.1033

Padrón, I., Fraga, I., & Acuna-Farina, C. (2020). Processing gender agreement errors in pleasant and unpleasant words: An ERP study at the sentence level. *Neuroscience Letters*, *714*, 134538. https://doi.org/10.1016/j.neulet.2019.134538

Palazova, M., Mantwill, K., Sommer, W., & Schacht, A. (2011). Are effects of emotion in single words non-lexical? Evidence from event-related brain potentials. *Neuropsychologia*, *49*(9), 2766–2775. https://doi.org/10.1016/j.neuropsychologia.2011.06.005

Palazova, M., Sommer, W., & Schacht, A. (2013). Interplay of emotional valence and concreteness in word processing: An event-related potential study with verbs. *Brain and Language*, *125*(3), 264–271. https://doi.org/10.1016/j.bandl.2013.02.008

Pulvermüller, F., & Shtyrov, Y. (2003). Automatic processing of grammar in the human brain as revealed by the mismatch negativity. *NeuroImage*, *20*(1), 159–172. https://doi.org/10.1016/S1053-8119(03)00261-1

Russell, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology*, *39*(6), 1161. https://doi.org/10.1037/h0077714

Scott, G. G., O'Donnell, P. J., Leuthold, H., & Sereno, S. C. (2009). Early emotion word processing: Evidence from event-related potentials. *Biological Psychology*, *80*(1), 95–104. https://doi.org/10.1016/j.biopsycho.2008.03.010

Tanner, D. (2015). On the left anterior negativity (LAN) in electrophysiological studies of morphosyntactic agreement: A commentary on "grammatical agreement processing in reading: ERP findings and future directions" by Molinaro et al., 2014. *Cortex*, *66*, 149–155. https://doi.org/10.1016/j.cortex.2014.04.007

Tanner, D. (2019). Robust neurocognitive individual differences in grammatical agreement processing: A latent variable approach. *Cortex*, *111*, 210–237. https://doi.org/10.1016/j.cortex.2018.10.011

Tanner, D., & Van Hell, J. G. (2014). ERPs reveal individual differences in morphosyntactic processing. *Neuropsychologia*, *56*, 289–301. https://doi.org/10.1016/j.neuropsychologia.2014.02.002

Trueswell, J. C., Tanenhaus, M. K., & Garnsey, S. M. (1994). Semantic influences on parsing: Use of thematic role information in syntactic ambiguity resolution. *Journal of Memory and Language*, *33*(3), 285–318. https://doi.org/https://doi.org/10.1006/jmla.1994.1014

Vieitez, L. (2019). *Why do not all negative words show the same effect in word recognition?:Behavioral and electrophysiological effects of arousal*, [unplublished Master's Thesis]. University of Rovira i Virgili, Tarragona, España.

Vigliocco, G., Kousta, S. T., Della Rosa, P. A., Vinson, D. P., Tettamanti, M., Devlin, J. T., & Cappa, S. F. (2014). The neural representation of abstract words: The role of emotion. *Cerebral Cortex*, *24*(7), 1767–1777. https://doi.org/10.1093/cercor/bht025

Vos, S. H., Gunter, T. C., Kolk, H. H., & Mulder, G. (2001). Working memory constraints on syntactic processing: An electrophysiological investigation. *Psychophysiology*, *38*(1), 41–63. https://doi.org/10.1111/1469-8986.3810041

Vosse, T., & Kempen, G. (2000). Syntactic structure assembly in human parsing: A computational model based on competitive inhibition and a lexicalist grammar. *Cognition*, *75*(2), 105–143. https://doi.org/10.1016/s0010-0277(00)00063-9

Wechsler, S. (2009). Agreement features. *Language and Linguistics Compass*, *3*(1), 384–405. https://doi.org/10.1111/j.1749-818X.2008.00100.x