Volume 23

Intercultural Studies and Foreign Language Learning

This book brings together 18 theoretical and empirical chapters that analyse the role of emotion (expression, perception, processing) and identity (notions and representations, construction, conflict) in the process of learning a second language. Studies on the differences in emotionality between L1 and L2 suggest that in L2 there is an alteration that, in many cases, manifests itself as a decrease in the affective load, which can lead to a certain indifference to the emotional content transmitted and to a lesser involvement in communication. It is also known that emotion plays a fundamental role in the construction of identity in a second language in the shaping of the self that feels and communicates and in the ability to cope with the learning process.

Most of the studies have focused on the understanding of these issues in balanced bilingual speakers, but there is little evidence on their functioning in speakers with other degrees of proficiency (the case of second language learners) and on their role in the learning process. Better understanding this question is fundamental for the improvement of everything related to second language acquisition. We need new and innovative approaches that lead to more effective programs, increased interest in language learning and the consolidation of multilingual societies.

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Processing of emotionality in languages

ISABEL FRAGA, ISABEL PADRÓN AND CARLOS ACUÑA-FARIÑA

The effects of emotionality on syntactic processing: Neural and behavioural evidence

ABSTRACT

Interest in the interplay between language and emotion has increased in recent years. In Spanish, a number of studies has been carried out in which the autonomy of grammar vis-a-vis lexical-semantic information, including emotional content, has been put to the test (largely in reference to Fodor's (1983) classic theory of informational encapsulation). In a series of experiments conducted in the Cognitive Processes and Behavior Research Group's lab (<https://www.usc.gal/pcc/web/index_en.html>) in which we used ambiguous relative clauses and gender agreement errors, we sought to better understand if and when the emotional connotation of words may impact morphosyntactic processing. Emotion was examined from the bidimensional perspective that ascribes to every lexical item a position in a scale defined in reference to two variables: pleasantness (vs unpleasantness) and arousal (or (relative) lack of it). We used classic behavioural tasks, such as the sentence completion task, the self-paced reading task and the grammatical judgement task, as well as the event-related potentials technique. Our findings reveal differential effects of emotionality across tasks and studies as a function of affective valence and arousal. Our studies also show that individual differences can be crucial.

KEYWORDS: valence, arousal, emotion-laden words, syntactic processing, ambiguous relative clauses, gender agreement, individual differences, event-related potentials (ERPs)

1. Introduction

In the field of psycholinguistics, a renewed interest in the relationship between language and emotion has been awakened in recent years. Here we will summarize the results of a series of experiments carried out in this area in which we have manipulated the affective dimension of words

in order to study their possible effects on syntactic processes. We discuss emotion from the bidimensional perspective that ascribes to every lexical item a position in an emotionality scale defined in reference to two variables: pleasantness (vs unpleasantness) and arousal (or (relative) lack of it). This is the first interface between emotion and 'language', as it measures emotion in the lexical component. However, this work further examines if there is another kind of interface between all that (emotion in isolated words) and the processing of syntactic structure. We examine this potential interface particularly by subjecting well-known morphosyntactic operations (like agreement) to the influence of emotionally charged vocabulary. The rationale for this is that if those operations change their behavioural or brain signature precisely when emotional vocabulary is in the scene, then the operations in question cannot be taken to be 'encapsulated', a la Fodor (1983). When discussing whether syntax is or is not an impregnable module in the mind, the classic way to proceed is to look for a semantic dimension (say, animacy or concreteness) and to see whether this impacts the processing of 'raw' syntax. Here we go one step beyond that and discuss whether a word's emotional 'connotation' does so too. Before we refer to recent strands of work aimed at clarifying this issue, we need to provide some background on morphosyntactic and ambiguous sentence processing as well as on the processing of emotional words.

1.1 The processing of morphosyntactic structure

Previous work by our team has focused on the processing of relative clauses and agreement. Take relative clauses (henceforth RCs) first. In a sentence like (1) below:

(1) Those students *who passed the exam* will start their holidays sooner

the noun *students* is modified by the RC *who passed the exam*. The job of this so-called *restrictive* RC is to restrict the reference of the previous head noun, so we understand that not all students passed the exam and that only those who did will vacation sooner. In sum, an RC narrows

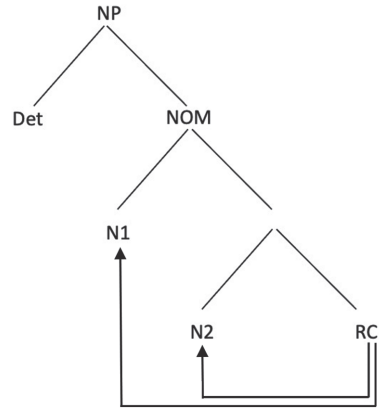
down the scope of reference of its head noun: in effect *the students who* … means 'not all students'. Consider (2) now:

(2) Somebody shot the servant of the actress who was on the balcony

This structure is ambiguous in that we really do not know whether the RC *who was on the balcony* modifies/restricts *servant* or *actress*, that is we do not know whether it is the servant or the actress that was on the balcony. The simplified tree in Figure 1 captures the permanent ambiguity.

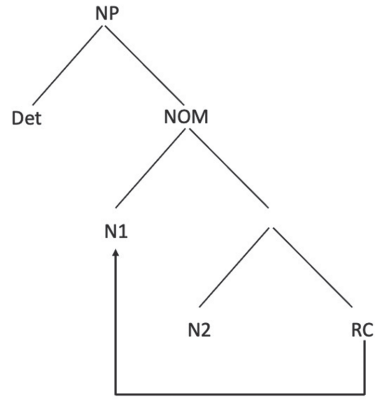
Psycholinguists feed on ambiguous structures like these because they can: (a) disambiguate them in one direction; (b) disambiguate them in the opposite direction; and (c) see which direction is preferred by the mind, to draw theoretical conclusions from that. Now, in grammar, the operation that links the RC to its head noun (*servant* or *actress*) is called *adjunction*. We can force adjunction to *servant* or to *actress* somewhat at will, especially in Spanish, as shown in the examples in Figures 2 and 3, respectively.

So, the modus operandi consists in giving participants sets of sentences such as those in Figures 2 and 3 and measuring which segment is read faster: *que estaba casad**o*** or *que estaba casad**a***. We then link the results of



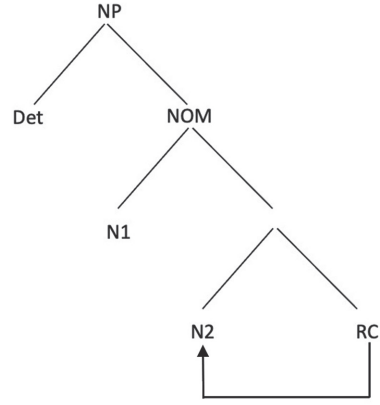
(They shot) the servant of the actress who was on the balcony

Figure 1. Syntactic structure corresponding to a permanent ambiguity.



Alguien disparó contra el criado de la actriz que estaba casad**o**

Figure 2. Syntactic structure corresponding to high attachment in Spanish.



Alguien disparó contra el criado de la actriz que estaba casad**a**

Figure 3. Syntactic structure corresponding to low attachment in Spanish.

such experiments to well-known theories. For instance, if *que estaba casad**a*** is read faster than *que estaba casad**o***, we may conclude that the human parser prefers to go by a *locality bias* to implement *computational economy*. This would take us to a defence of something like Chomskyan postulates.

Conversely, if *que estaba casad**a*** is read more slowly, then we may wish to stress the role of other non-arboreal (extra-syntactic) parameters, such as the perceived relevance of the two lexical competitors: is a sentence like *somebody shot the servant of the actress* … more about the servant or about the actress? What about a slight modification that introduces a prior context with three servants but only one actress? If we then say *somebody shot the servant of the actress who …,* is it not natural to expect the RC to subdefine which servant in particular we are talking about? Notice that these latter considerations involve interpretations that tap either meaning directly or meaning in context, but they do not tap a preferred syntactic tree.

Ever since Cuetos and Mitchell (1988) discovered that British and Spanish speakers differed on their adjunction patterns (with the British opting for locality and the Spanish for an anti-locality preference), research on this type of ambiguity has skyrocketed (see Acuña-Fariña, Fraga, García-Orza and Piñeiro, 2009; Grillo and Costa, 2014 for reviews). Non-syntactic explanations that explore the lexical dimension have often been proposed. For instance, in a self-paced reading study, Desmet, Brysbaert and De Baecke (2002) examined Dutch and proved that when the first noun coded an animate referent and the second an inanimate one (say, *the student with the suitcase that* …) the RC was preferentially linked high to the first noun in that language. A little later, using eye-tracking, Desmet et al. (2006) provided more evidence for the animacy manipulation and extended their lexical approach to a new dimension: the concrete/abstract distinction. They found that when the first noun coded a referent that was both animate and concrete (*brother*, *aunt*) as opposed to animate and abstract (*the UN*, *the police*), adjunction to it increased significantly in Dutch. In both a corpus study and a self-paced reading study, Acuña-Fariña et al. (2009) offered similar evidence of the animacy manipulation in Spanish. In section 3.1 we review our work with an emotionality manipulation. That is, we face the question: what happens with RC adjunction when one of the two nouns in the previous nominal compound scores much higher in the emotionality scale than its competitor? Will it attract the RC?

Consider agreement now. Take a sentence like (3) below, from Spanish, for instance:

(3) Tod*os* l*os* camion*es* alt*os* y roj*os* est*án* mal aparcad*os*

This sentence takes only some two seconds to output. Within those two seconds, however, and only with agreement in focus now, the mind must establish twelve agreement operations: the head noun of the subject noun phrase (*camiones*) bears the morphological features *masc* + *plural*. All of its satellites must redundantly and alliteratively replicate those features: the predeterminer *todos*, the determiner *los*, the modifiers *altos* and *rojos*, and the predicative complement after the verb, *aparcados*. Then the verb itself (*están*) must replicate the plural feature too. This morphological excess is really not necessary. English provides a convenient contrast. The translation of (3) in that language shows that two features manage to code exactly the same meaning:

(4) All the tall, red truck**s are** badly parked.

Note that the mind must keep store of the abstract morphological features (masc + pl) because they may have to be re-coded at a distance (which is why linguists define agreement as a *long-distance dependency*): in (3) the head noun *camiones* appears in a preverbal phrase, the subject phrase, but the predicative complement *aparcados* appears postverbally, and the distance can actually easily increase. Underlining shows that in (5):

(5) Todos los camion**es** *altos y rojos están evidente y casi diría que deliberadamente mal* aparcad**os**

Psycholinguistically, one may study numerous aspects of the grammar of agreement: for example, whether the mind distinguishes co-indexations involving a. conceptual gender (*niñ-o alt-o/niñ-a alt-a*) from those involving arbitrary gender (*mes-a alt-a/barc-o alt-o*); b. gender (of whatever kind: *niñ-a*, *mes-a*) from number (*coche* vs *coche-s*); agreement in the short distances (*niñ-o alt-o*) from agreement in the long ones (example 5 above), etc. The ERP methodology has been greatly influential in uncovering how the mind reacts to *violations* in all these cases. For instance, Barber and Carreiras (2005) examined violations of determiner + noun sequences in Spanish

(e.g. gender: *el lago* vs **la lago*; number: *el lago* vs **el lagos*) and adjective + noun ones (e.g. gender: *arroyo helado* vs **arroyo helada*; number: *arroyo helado* vs **arroyo helados*). The most prevalent brain signal, at least in morphologically rich languages like Spanish, Italian or German, is a biphasic pattern involving two ERP components: a left anterior negativity (LAN) in the 300–450 ms range followed by a positive shift that starts peaking at about 600 ms (P600) post stimulus (the anomaly) and that is distributed across centro-parietal electrodes (see Molinaro et al. 2011 for a review). The most typical interpretation of these findings is that LAN taps early, automatic syntactic processes such as feature match (-o, -o, -o, etc.), whereas P600 rather reflects both surprise (first) and strategically oriented repair strategies (later). Briefly said, higher LAN and P600 amplitudes are usually interpreted in terms of greater processing difficulty. In sum, the view that arises from these studies is that agreement co-indexations are fast-tracked, automatic, encapsulated operations running on formal rails. So far, research has shown that semantic manipulations rarely impact their processing.

Both studies on ambiguous RCs and gender agreement processing have been conducted with different behavioural tasks and EEG techniques that we briefly describe in Section 4. Ultimately, we are interested in testing whether at some point along the time course of reading, neural correlates (and/or behavioural measures) are impacted by the presence of emotional words.

1.2 The dimensional perspective and the processing of emotional words

In the words of Bradley, Codispoti, Cuthbert and Lang (2001: 276), emotion can be seen to be

> (…) fundamentally organized around two motivational systems, one appetitive and one defensive, that have evolved to mediate transactions in the environment that either promote or threaten physical survival (…). The defence system is primarily activated in contexts involving threat, with a basic behavioural repertoire built on withdrawal, escape, and attack. Conversely, the appetitive system is activated in contexts that promote survival, including sustenance, procreation, and nurturance, with a basic behavioural repertoire of ingestion, copulation, and caregiving. These

> systems are implemented by neural circuits in the brain, presumably with common outputs to structures mediating the somatic and autonomic physiological systems involved in attention and action …

These two systems, the basis of current bidimensional models, make it possible to categorize the entire range of human emotions in a manageable, workable way. The two primary dimensions now widely recognized are *valence* and *arousal*. Valence refers to degrees of pleasantness (*jacuzzi*) and unpleasantness (*arthritis*). Arousal refers to the states of being calm (the picture of someone asleep) or excited (the picture of piles of bodies in Auschwitz). As Díaz-Lago, Fraga and Acuña-Fariña (2015: 80) note, the 'distribution of emotional stimuli in the affective space defined by these two dimensions tends to show a typical boomerang shape, since unpleasant and pleasant stimuli (words, pictures, and sounds) are usually rated as having higher arousal than neutral ones' (see Figure 4).

Work on emotion based on this bidimensional perspective received great impetus when Bradley and Lang (1999) published their *ANEW*

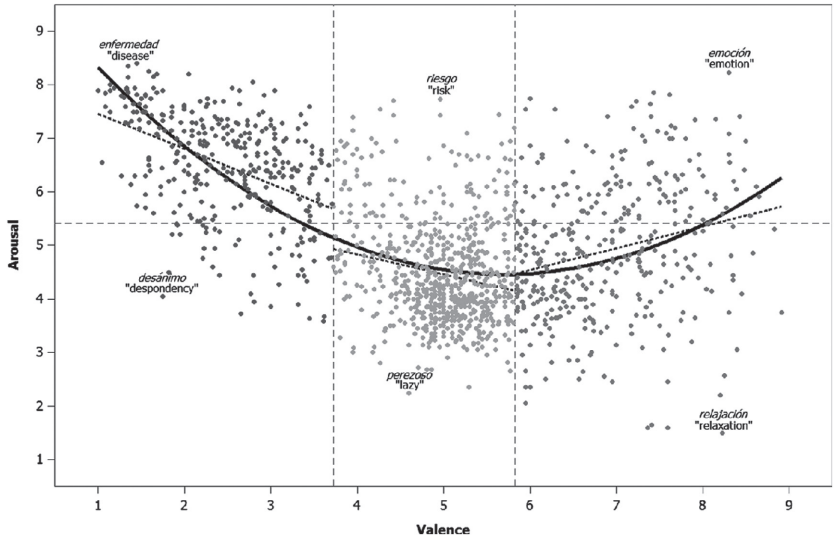


Figure 4. The U-shape of affective space (taken from Guasch et al. 2016).

(Affective Norms for English Words) database. For the first time, psycholinguists could count on two important things to study emotion rigorously: a) an actual database of English words along the two referred dimensions, which could be used in many experiments, and b) a procedure to extend that mechanism to other languages. Soon, Redondo, Fraga, Padrón and Comesaña (2007) published the Spanish adaptation of the ANEW, thus providing values for emotional words in the valence, arousal and dominance dimensions. Following the original procedure, the authors used the Self-Assessment Manikin (SAM, Bradley and Lang, 1994), a pictorial instrument that allows researchers to ask participants for their subjective ratings in the two main affective dimensions. The scales range from 1 to 9, 1 being the value for a word perceived as very unpleasant (*death*) and 9 the value estimated for a highly pleasant one (*success*). Regarding arousal, 1 corresponds to a low arousal word (i.e. *peace*) and 9 to a highly arousing, exciting word (*murder*). The SAM tool has been widely used to develop many other word databases in Spanish and other languages (e.g. Soares, Comesaña, Pinheiro, Simões and Frade, 2012; Montefinese, Ambrosini, Fairfield and Mammarella, 2014; Schmidtke, Schröder, Jacobs and Conrad, 2014; Guash, Ferré and Fraga, 2016).

Díaz-Lago et al. (2015: 81) note a crucial feature of emotional vocabulary which is worth emphasizing here:

> A key feature of emotional words is that, whereas they are clearly 'meaningful', in as much as the information they provide is relevant for an individual, it seems that valence and arousal effects in word processing are relatively independent of lexicosemantic variables (Citron et al. 2014a). For instance, the words 'slug', 'cancer' and 'depression' are all negative (and highly arousing) but belong to completely different semantic categories. On the contrary, words like 'rape' and 'attraction' share a sexual content but can hardly be considered similar as regards their emotional valence or even their arousal. Thus, an emotional word will not only activate knowledge along semantic dimensions but also along specific emotional dimensions (Delaney-Busch et al. 2013). This means that, even though there may be an interaction between meaning and emotional content, and even though emotional words may exhibit lexical properties (e.g. frequency, age of acquisition, etc.) as well as semantic properties (e.g. imageability), affective valence and arousal influence the processing of written words beyond such properties. (Citron et al. 2014b)

It is then important to distinguish between so-called emotion-laden words and emotion-label words, that is, those words denoting emotions directly, such as *happiness*, *anger*, or *sad* (Pavlenko, 2008). Pérez-Sánchez, Stadthagen-Gonzalez and Guasch (2021) provide prototypicality values for more than one thousand emotion words in Spanish. It must be said, though, that most research on language and emotion – including the studies described here – has used the first type of words, since their number is much higher.

Behavioural studies using words in isolation have made it clear that there is something distinct about emotional vocabulary. For instance, word recognition is faster with emotional words, especially for pleasant ones (Citron, Weekes and Ferstl, 2014). In the Stroop task, negative words have also been shown to cause greater interference than neutral controls (Frings, Englert, Wentura and Bermeitinger, 2010). Recall is also positively affected by a word's emotionality. A conservative conclusion based on these studies (see Citron, 2012 for a review) is that not only is emotional vocabulary recognizably distinct but that negative and positive valence and high or low arousal are distinct from one another too, not to mention the possible interactions between both variables.

Electrophysiological studies have rather consistently cast two main effects (Citron, 2012; Kissler, Assadollahi and Herbert, 2006). The first one is the so-called *Early Posterior Negativity* (Citron, 2012; Scott, O'Donnell, Leuthold and Sereno, 2009), a negative deflection produced by emotional words that peaks at circa 200–300 ms in posterior sites. This is a consistent finding but in fact, less consistently, differential effects have also been reported as early as in the 100 ms time window in negative waves (Scott et al., 2009; Wong, Bernat, Snodgrass and Shevrin, 2004; Hinojosa, Mercado, Albert, Barjola, Peláez and Villalba-García, 2015) and in the 200 ms range in positive ones (Herbert, Kissler, Junghofer, Peyk and Rockstroh 2006). These early signatures are standardly interpreted to indicate that words with salient emotional connotations 'launch a cascade of automatic processes that prevail temporarily over linguistic processes', including pure lexical access (Fraga, Padrón, Acuña-Fariña and Díaz-Lago, 2017). The second consistent effect is a positive-going wave in the 500–800 ms range, with a parieto-central distribution. This is known as the *Late Positive Complex*

(LPC) or *Late Posterior Positivity* (LPP; Citron, 2012; Fischler and Bradley, 2006; Kissler et al., 2009), and its usual interpretation is that it registers high-level, strategic control (Citron,2012), and possibly some kind of sustained evaluative processing (Delaney-Busch, Wilkie and Kuperberg, 2016). Cumulatively, and conservatively, the broad picture provided by these two components seems to indicate that the processing of emotion-laden words reliably differs from that of neutral words.

2. Methodology

In our studies on ambiguous RCs, we used the sentence completion task (Fraga, Piñeiro, Acuña-Fariña, Redondo and García-Orza, 2012) and the self-paced reading task (García-Orza, Gavilán, Fraga and Ferré, 2017). The sentence completion task consists in presenting participants with sentence preambles that they must complete with the first words that come to their minds, forming meaningful and plausible sentences. In a series of studies, we used experimental sentences with the structure NP–V–NP1–de–NP2–que … (NP–V–NP1–of–NP2–which …, where V = verb), such as 'La pareja estaba en la fase del divorcio que …' [The couple was in the phase of the divorce that …], where *phase* is a neutral word and *divorce* an unpleasant one. The dependent variable (DV) is the percentage of completions referring to NP1 and NP2.

In the self-paced reading task participants are asked to read sentences which appear word by word on the screen at their own pace, pressing a key to be able to read the following word in the sentence. In our studies, the experimental items comprised disambiguated sentences with the following structure: NP-V-NP1-of-NP2-RC, such as 'El guardia vigilaba el dinero$_{masc}$ de la máquina$_{fem}$ que estaba cargado$_{masc}$/cargada$_{fem}$ en el camión' [The guard watched the money*masc* of the machine*fem* that was loaded*masc/fem* on the truck]. Here, the main DVs are the hits and RTs in the target word (*cargado/cargada*), which is the disambiguating word, since depending on its gender mark the RC refers to the NP1 or the NP2.

Finally, we used the event-related potential (ERP) technique to study the neural correlates of processing both ambiguous RCs and gender agreement. Its high resolution makes it a very useful tool for the study and analysis of neural correlates of syntactic processing. Thus, we recorded the electrophysiological activity (EEG) while participants performed the behavioural tasks. As previously mentioned, the main ERP effect of syntactic errors is a biphasic pattern composed by the LAN/N400 negativities around 300–450 ms in left-anterior (LAN) and/or fronto-central sites (N400), followed by a positivity generally localized in centro-parietal regions, called P600.

We focused on the P600 component to study the processing of ambiguous sentences with emotional words (Piñeiro, Galdo, Fraga, Acuña-Fariña and Barber, 2009). It is well known that the amplitude of this wave increases in sentences that include syntactic violations or that, as in our case, are temporarily ambiguous though grammatically correct. Previous studies in Spanish had demonstrated that P600 amplitudes increase when a sentence containing an ambiguous RC is disambiguated towards NP2 compared to NP1, confirming that the election of the latter as the subject of the RC is the structural preference in this language (Carreiras, Salillas and Barber, 2004; but see Aguilar, Ferré, Gavilán, Hinojosa and Demestre, 2021). We went one step further with the aim of investigating whether the presence of an emotional word can affect processing by reducing the P600 amplitude in disambiguated sentences towards NP2, which would reflect an influence of emotionality on syntactic processing.

To sum up, in all the RC sentence studies we manipulated the emotionality of the nouns in the complex NP with the general aim of testing whether the structural preference of Spanish native speakers to disambiguate the RC towards the NP1 can be reversed by the presence of an emotional word in NP2.

Regarding gender agreement, we used the grammaticality judgement task across a new series of ERP studies. In this task, participants are presented with gender match (the round*fem* hamburger*fem*) and mismatch (the round*masc* hamburger*fem*) trials while neural correlates are recorded along the time course of processing. As noted, morphosyntactic violations give rise to wider amplitudes in two typical components, LAN and P600

Again, in our studies we manipulated the emotionality of the adjective to check if the brain signature associated with the detection of agreement errors differs in pleasant, unpleasant and neutral words (e.g. *la hamburguesa sabroso/podrido/redondo* [the tasty/rotten/round hamburger], respectively). As we will see later, our results go far beyond the classic biphasic pattern generally found in the literature.

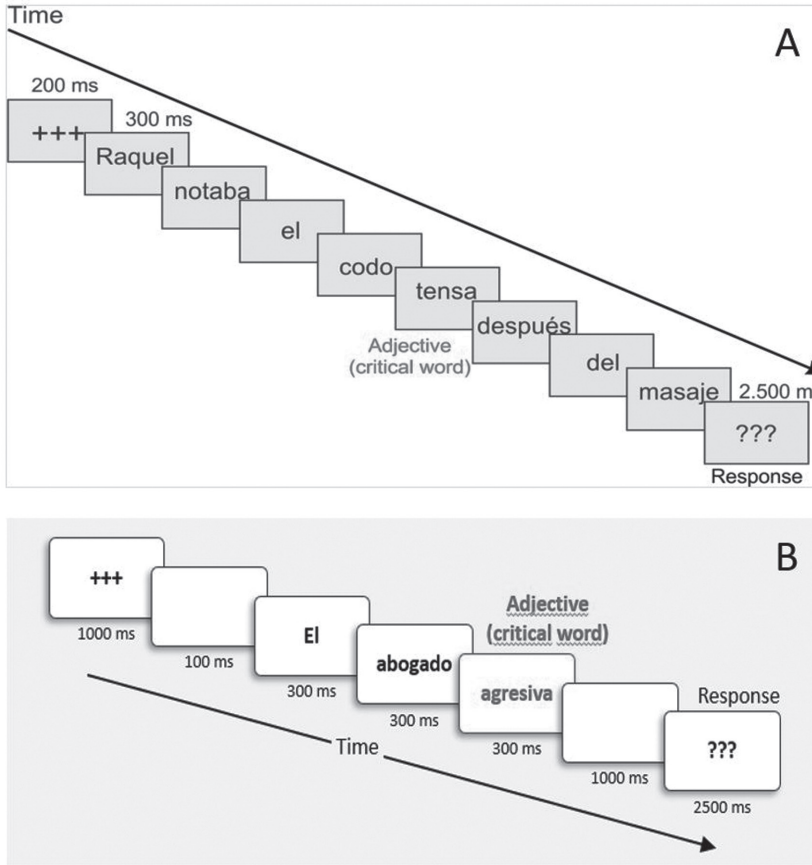


Figure 5. Schematic representation of the sequence of stimuli in a single trial in Experiments with long sentences (A) and in Experiments with NPs (B).

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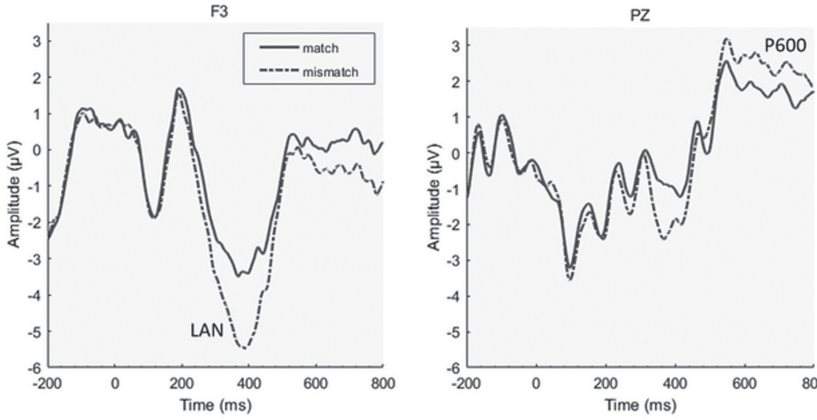

Figure 6. Grand mean averaged ERPs elicited by match and mismatch conditions with neutral adjectives registered at typical electrode positions for the LAN (F_3) and P600 time windows (PZ).

3. Results

3.1 The effect of emotionality on the processing of ambiguous RCs

As previously indicated, we conducted several completion studies to test the impact of valence and arousal on the proportion of completions towards NP2 when the complex NP contains emotional words. In one of them (Fraga at al., 2012, Exp. 1), we manipulated affective valence and found that, compared with a control condition in which both nouns in the complex NP were neutral and in which the NP1 was the preferred host for the ambiguous RC (i.e. the classic Spanish high-attachment preference), whenever a neutral word was in the NP1 and an emotional one was in the NP2, the latter site was the preferred site. Importantly, this 'reversal' effect was obtained independently of word valence (pleasant or unpleasant). Furthermore, there were no significant differences between NPs with a pleasant word in the NP1 and an unpleasant one in NP2 (P-U condition) and NPs with an unpleasant word in the NP1 and a pleasant

one in NP2 (U-P condition), as in both experimental conditions the participants replaced their default high-attachment preference by a low attachment one. This indicated, for the first time, that emotional words can indeed affect syntactic processes.

After a preliminary interim experiment in which we found that high arousal words seemed to pull the adjunction to NP2 more than low arousal ones (Fraga at al., 2012, Exp. 2), we conducted a new completion study (Exp. 3). On this occasion, we were specifically interested in testing whether high arousal pleasant words would also attract the RC more than low arousal ones irrespective of their position in the complex NP.[1] Thus, our hypothesis was that this would lead to significantly higher proportions of NP1 versus NP2 elections when high arousal words were embedded in NP1 and NP2, respectively. And this was just what we found, revealing that arousal can be a critical variable to reverse syntactic preferences in native speakers of Spanish (see Figure 7).

This set of results seems to show that the emotional connotation of words – a variable not considered so far – can influence syntactic processing. However, given the offline nature of the task, it does not provide evidence of when precisely the emotionality of the word *infiltrates* syntactic processing. The sentence completion task is also a production task that begins with a conceptual structure and can hence be affected by various conscious strategies of the participants. Thus, the role of semantics may be quite strong here in as much as we are manipulating a lexico-semantic characteristic. Likewise, it is important to point out that a lexical operation, and not only a syntactic one, is also entailed in this task, as proposed in the Attachment-Binding model (Hemforth, Konieczny and Scheepers, 2000; Konieczny and Hemforth, 2000). In this sense, not only must the RC be syntactically attached, but also the relative pronoun (who/which/that) must be bound to its antecedent (i.e. there will also be an anaphor resolution process), either the NP1 or the NP2. Thus, it seems reasonable to assume that a lexical process is affected by a lexical variable. It could be, therefore, that the results found were specific to this task, so we were

1 We used pleasant words because, as shown in Figure 7 unpleasant words with low levels of arousal are scarce.

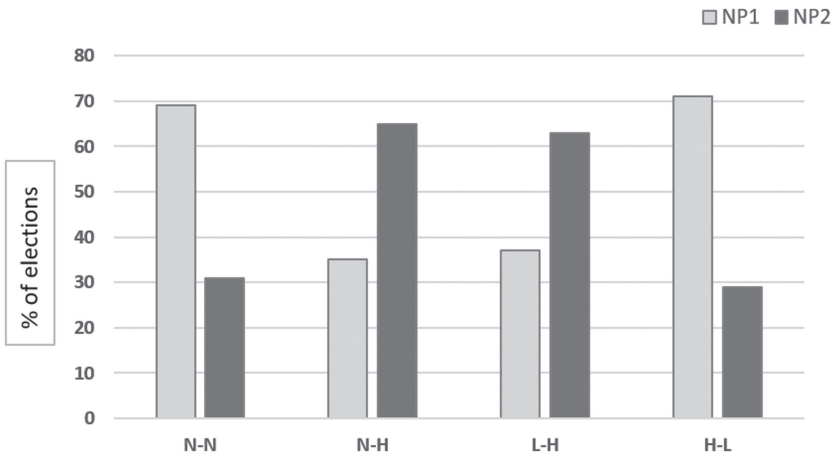

Figure 7. Percentages of elections to NP1 and NP2 in the processing of ambiguous Relative Clauses (RCs) with emotional words. N-N: neutral words in NP1 and NP2; N-H: neutral word in NP1 and high arousal word in NP2; L-H: low arousal word in NP1 and high arousal word in NP2; H-L: high arousal word in NP1 and low arousal word in NP2.

concerned about their replicability and reliability and felt that more fine-grained tasks and techniques were required.

This led us to conduct an online comprehension study using the self-paced reading task (García-Orza et al., 2017). We used two types of NPs, in such a way that in one of the experimental conditions NP1 included an emotional word and NP2 a neutral one (E-N condition), and in the other, NP1 included a neutral word and NP2 an emotional one (N-E condition). Additionally, two versions of each sentence were created; the RC was forced to a high attachment in one case and to a low attachment in the other. Gender morphology was manipulated to create such sentences as shown in the following example:

> E-N: '*El guardia vigilaba el dinero*$_{masc}$ *de la máquina*$_{fem}$*/que estaba/cargado*$_{masc}$ *- cargada*$_{fem}$*/en el/camión*' [The guard watched the money of the machine that was loaded on the truck]

N-E: '*El guardia vigilaba la máquina*$_{fem}$ *del dinero*$_{masc}$*/que estaba cargada*$_{fem}$ *-cargado*$_{masc}$*/ en el/ camión*' [The guard watched the machine of money that was loaded on the truck]

Sentences were divided into four regions from the beginning of the RC (as indicated by the slashes in the examples). Although we were primarily interested in the disambiguating word (*cargado-a*), we ran analyses for the four regions. For the sake of brevity, we will describe here the results concerning the main region (the disambiguating word) and the region that includes the two words following the disambiguating word.

Based on our previous studies, we expected a reversal of the typical Spanish high-attachment preference in the shape of lower reading times in sentences disambiguated towards NP2 in the N-E condition. However, while our results confirmed a solid preference for attaching the RC to NP1 in the E-N condition, in the N-E condition this preference disappeared, but was not reversed (RTs in N-E sentences disambiguated towards NP1 and NP2 were not significantly different). Therefore, we confirmed for the first time in online data that the presence of emotional words has an impact on RC attachment preferences, but this effect appears to be short-lived and relatively weak when the emotional word is in the NP2, and hence it is not so strong as those in our sentence completion studies.

In view of these results, we moved forward to the ERP technique, with the aim of testing if emotionality can truly affect RC disambiguation early on during processing (Piñeiro et al., 2009). To do that, we used two experimental conditions: one condition in which both nouns in the complex NP were neutral (N-N condition) and another one in which the NP1 contained a neutral word while the NP2 contained a high arousal pleasant one (N-E condition), as can be seen in the following examples:

N-N: '*Las mariposas revoloteaban por* ***la calle del mercado*** *que estaba* <u>*abarrotada/o*</u> *de gente*' [Butterflies flitted down the street of the market which was packed with people]

N-E: *'El periodista escogió* ***la historia del triunfo*** *que había permanecido* <u>*oculta/o*</u> *para el público*' [The journalist chose the story of the triumph that had been hidden from the public]

In both cases, sentences disambiguated to NP1 vs NP2 were presented to the participants while their brain activity was recorded. The results

showed greater P600 amplitudes in sentences disambiguated towards NP2, confirming the native Spanish speakers' bias towards high adjunction. Critically, this effect was obtained in both experimental conditions, N-N and N-E, without finding any significant difference between the two. This seems to indicate that pleasantness does not affect ambiguity resolution in comprehension tasks, at least in early stages of processing.

In summary, our findings show remarkable differences in the effects of word emotionality on the resolution of ambiguous RCs across tasks: while clear behavioural effects were found in a sentence completion task, where the presence of high arousal words (particularly, pleasant words) proved to be a powerful RC attractor when they were located in NP2 (i.e. in the non-preferred attachment site), these effects were temporary and weaker in an online behavioural comprehension task, and were absent in the ERP study in which the early NP1 preference was confirmed. Ultimately, the set of results is not homogeneous, making it hard for us to determine to what extent emotional words can indeed affect syntactic processing.

3.2 Neural correlates of morphosyntactic and affective processing

At the time of our study on the processing of ambiguous RCs in sentence completion tasks, a paper by Martín-Loeches, Fernández, Schacht, Sommer, Casado, Jiménez-Ortega and Fondevila (2012) was published in which the effect of emotional words on the processing of number agreement errors was investigated. In this ERP study (Exp. 1), it was found that the LAN grammaticality effect increased in the presence of unpleasant words compared to neutral words. According to the authors, this could be revealing an interaction between grammaticality and emotionality at early stages of processing. In contrast, in the P600 wave, the emotionality of the words did not affect the grammatical effect usually obtained. Later, Hinojosa, Albert, Fernández-Folgueiras, Santaniello, López-Bachiller, Sebastián, Sánchez-Carmona and Pozo (2014) also found a significant interaction between grammaticality and emotionality in the LAN component, but, on this occasion, in the opposite direction. Thus, while, as expected, in the control condition where the adjective was neutral the LAN

amplitudes were greater when there was a gender mismatch between the noun and the following adjective (e.g. 'el camarero alta') compared to the match condition (e.g. 'el camarero alto'), in the condition where the adjective was unpleasant (e.g. 'el camarero furioso/a'), this effect disappeared. The authors interpreted these results in terms of a facilitation effect of morphosyntactic violations in the presence of unpleasant words. As well as in the prior study, Hinojosa et al. (2014) did not find any interaction between grammar and emotion in the P600 window.

There are several differences and methodological aspects in these studies that might explain their discrepant results on the LAN component (Fraga, 2020). In the first study, number agreement violations, short clauses and pleasant vs unpleasant vs neutral words were used. In the second, gender agreement errors, NPs with the form Det+Noun+Adjective and unpleasant vs neutral words were selected. Furthermore, unpleasant words in the study by Martín-Loeches et al. (2012) were low arousal words, while in the study by Hinojosa et al. (2014) they were high arousal words (see Jiménez-Ortega, Espuny, de Tejada, Vargas-Rivero and Martín-Loeches, 2017, for similar LAN findings in a further study with high arousal unpleasant adjectives).

We designed a new series of experiments with a careful methodological control to shed some light on these differing results and, above all, on the interaction between grammaticality and emotionality. The general aim was to try to draw reliable conclusions about whether this interaction is indeed possible and under what circumstances it could occur. Do pleasant and unpleasant words yield similar effects? What about the arousal level? And about participants? Is everyone impacted by emotionality to the same extent and at the same time when processing morphosyntactic anomalies?

We conducted four ERP studies using long sentences with the structure showed below. In all these sentences there was a NP including a head noun and an adjective that could match or mismatch the noun in gender (*el codo tenso/a* [the tense elbow]), and the adjective could be pleasant, unpleasant or neutral, as in the following examples:

Pleasant: *'La joven se comió* ***una hamburguesa tierna/o*** *con patatas'*

[The young woman ate a tender hamburger with fries]

Neutral: *'La joven se comió **una hamburguesa redonda/o** con patatas'*

[The young woman ate a round hamburger with fries]

Unpleasant*: 'La joven se comió una **hamburguesa podrida/o** con patatas'*

[The young woman ate a rotten hamburger with fries]

In the first experiment, neutral and pleasant adjectives were used (Díaz-Lago et al., 2015); in the second experiment, neutral and unpleasant ones (Fraga et al., 2017, Exp. 1); in the third, pleasant, unpleasant and neutral ones (Fraga et al., 2017, Exp. 2); finally, in the fourth experiment, only pleasant and unpleasant adjectives were selected (Padrón, Fraga and Acuna-Farina, 2020). Note that sentences, nouns and adjectives were the same across studies, allowing us to make direct comparisons. Likewise, in all these experiments the emotional adjectives had a moderate level of arousal (around 6 in a scale from 1 to 9), hence differing from neutral ones in both arousal and valence. As expected, in all these studies we found the classic LAN and P600 effects, with greater amplitudes in mismatch than in match conditions. Most importantly, contrary to the studies reported above, this occurred in all cases regardless of the emotionality of the words (see Figure 8).

It is worth noting that, in addition to the grammaticality effect, in Experiment 1 we also found an emotionality effect in the 600 ms window. Thus, pleasant words evoked greater amplitudes than neutral ones in both the match and the mismatch conditions, which is suggestive of an LPC effect that would indicate that, in line with previous literature, sentences with pleasant words were re-evaluated to a greater extent than sentences with neutral ones (Díaz-Lago et al., 2015). On the contrary, in Exp. 3, the sentences with either pleasant or unpleasant words evoked lower P600 amplitudes in match conditions than neutral words, thus showing a relatively late processing advantage for emotional adjectives. However, although our findings showed the expected grammatical and emotional effects, these proved to be independent of each other. Therefore, they do not align with previous studies, such as those of Martín-Loeches et al. (2012) and Hinojosa et al. (2014), in which the interaction between grammaticality and emotionality was significant, particularly in the case of unpleasant words. Yet, as already indicated, all these studies differ in the linguistic unit used, the type of grammatical feature tested and the level of arousal of the

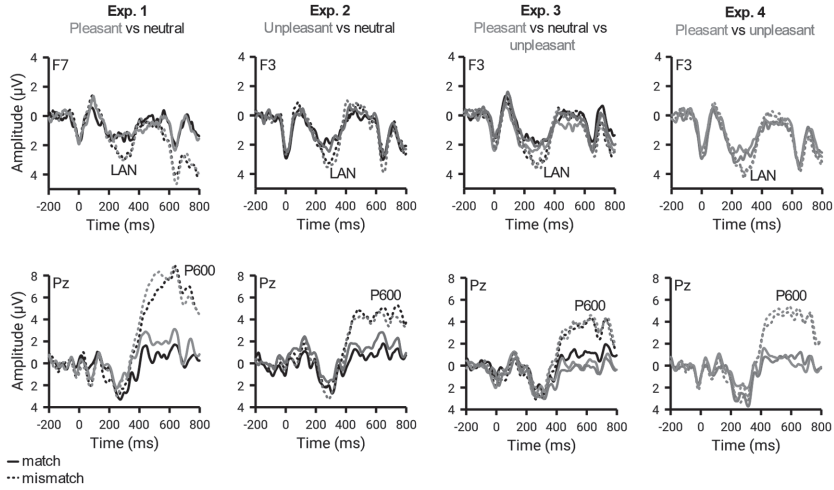

Figure 8. Experiments with long sentences: Grand mean averaged ERP waveforms for match and mismatch conditions elicited by pleasant, neutral, and unpleasant adjectives at typical electrode positions for the LAN (F7, F3) and P600 time windows (PZ).

adjectives, among other factors (Fraga, 2020). So, to try to shed light on these discrepancies we ran two new experiments where we used NPs with animate nouns (e.g. *el/la camarero/a furioso/a*, i.e. with biological rather than arbitrary gender), and not sentences. We were particularly interested in the comparison between our studies and that of Hinojosa et al. (2014) since both used a gender agreement task and similar procedures. Furthermore, although in our previous studies we did not find differences between pleasant and unpleasant words, the available evidence is not so clear when it comes to the neural correlates and behavioural effects of the latter (Vieitez, Haro, Ferré, Padrón and Fraga, 2021), so in one of the experiments we compared negative and neutral adjectives, and in the other, we compared positive and neutral ones. The aim was to test the extent to which the brain signature of morphosyntactic violations can be sensitive to affective valence when the level of arousal is controlled.

Before summarizing these results, it should be mentioned that recent research has demonstrated that there are individual differences when processing morphosyntactic violations, in that (a) not everyone exhibits higher

LAN amplitudes, (b) most people show the classic P600 grammaticality effect, and (c) only a small percentage of participants shows the biphasic LAN-P600 pattern (Tanner and Van Hell, 2014; Caffarra, Mendoza and Davidson, 2019; Tanner, 2019). Taking this into consideration, we proceeded to analyse the ERP effects in the grand averages of participants as well as to run separate analyses for those individuals showing negative-dominant and positive-dominant ERP responses, and we did so in both experiments (for a description of the procedure used to assign participants to groups, see Tanner et al., 2014; Fraga, Padrón and Hinojosa, 2021).

In Exp. 1 (unpleasant words), omnibus ANOVAs showed (1) an early (marginal) effect of emotionality (N100, an indicator of the preferential capture of attention by negative content); (2) grammaticality and emotionality effects and, for the first time, a significant interaction between them in the LAN time window; and (3) a grammaticality effect in the P600 component (see Figure 9). This would reveal that emotionality is temporally prioritized in the brain, while grammaticality is analysed later. Focusing on the LAN time window it is noteworthy that, in our study, the amplitude enhancement in gender agreement errors was observed in unpleasant words, but not in neutral ones. This does not match the results of either Hinojosa et al. (2014), who obtained a LAN cancellation in high arousal unpleasant words, or Martín-Loeches et al. (2012), who obtained an augmented LAN effect in low arousal unpleasant words relative to neutral ones.

However, separate analyses by groups shed light on this and revealed clear differences between those participants with a negativity profile and those with a positivity profile (see Table 1). Thus, the positivity profile group's results showed enhanced N100 and N400 amplitudes in unpleasant adjectives compared to neutral ones as well as enhanced P600 amplitudes in mismatch relative to match stimuli. Importantly, the LAN interaction between grammaticality and emotionality was only significant in this group of participants and 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, with higher amplitudes in the neutral match condition than in the neutral mismatch one (see Fraga et al. 2021, for details). Contrarily, although the negative dominance group also showed enhanced N100 amplitudes in unpleasant words, they showed the typical

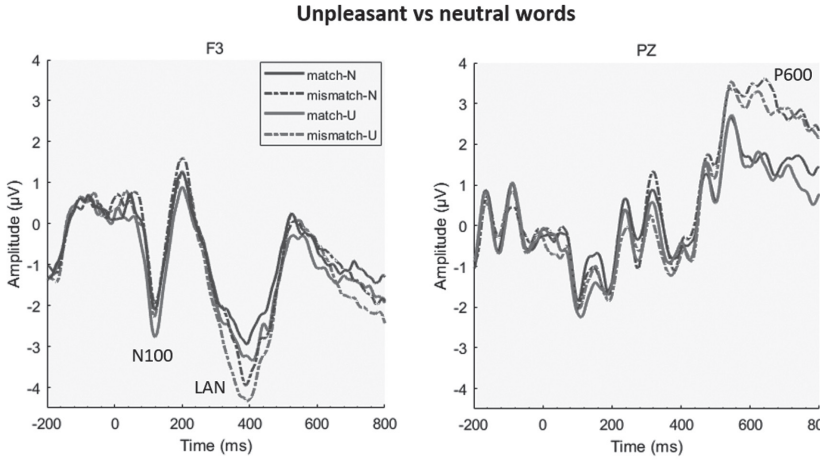

Figure 9. Experiments with noun phrases: Grand mean averaged ERP waveforms for match and mismatch conditions elicited by unpleasant (red line) and neutral (grey line) adjectives at typical electrode positions for the LAN (F3) and P600 time windows (PZ).

LAN grammaticality effect exclusively, that is, higher amplitudes in mismatch items regardless of the emotionality of the adjectives.

Several conclusions can be drawn. First, there are indeed individual differences in morphosyntactic processing. Second, the influence of emotionality on grammatical processing may emerge only in certain participants at the neural level, which is remarkably relevant. Third, there also appear to be differences between the two participant profiles in terms of the temporal priority that they give to the processing of grammatical and lexico-semantic features, or more specifically to gender agreement and unpleasantness, when performing a grammaticality judgement task. On the one hand, the negative dominance group seems to have 'temporarily prioritized 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 …' (Fraga et al. 2021: 1229). On the other hand, the positive dominance group showed both effects in the N100 and LAN time windows, also showing an interaction between grammaticality and emotionality at the latter one that could suggest

'a processing advantage during the early detection of morphosyntactic errors in the unpleasant condition' (Fraga et al. 2021: 1229). This is a similar finding to that obtained by Hinojosa et al. (2014) but that should be confirmed in further research (since, unlike these authors, our participants did not show the classic LAN effect in neutral words). Also, they showed the classic P600 grammaticality effect. Finally, it is interesting to note that while the negativity profile group 'appeared to perform slightly worse in unpleasant trials' (Fraga et al. 2021: 1229), the positivity profile group appeared to perform better in the unpleasant condition than in the neutral one.

Regarding the effects of pleasant words on the processing of gender agreement anomalies in NPs (see Figure 10), preliminary results of Exp. 2 (Padrón et al., submitted) confirm the two different neural profiles of participants, also revealing some interesting differences relative to unpleasant adjectives. In a few words, the negative dominance group showed the grammaticality effect in both early (N100) and intermediate (EPN) components, as well as in the LAN component (greater amplitudes in mismatch trials in all cases). Also, they showed a marginal facilitation effect of emotional words in the form of reduced N400 amplitudes. In turn, the positive dominance group did not show any effect until this time window, where the same emotionality effect was obtained. Moreover, these participants showed the usual enhanced P600 amplitude in mismatch trials as well as an enhanced LPC for pleasant adjectives, thus replicating the Díaz-Lago et al.'s (2015) results. At the behavioural level, faster RTs were registered for both mismatch and pleasant trials than for match and neutral ones, respectively, in the two groups. Critically, no interaction was recorded in either group (see Table 2).

If we consider the results of Exp. 1 and 2 together, the first outstanding point is that the neural correlate patterns in the grammaticality task are different in pleasant and unpleasant adjectives. Second, these patterns are more homogeneous in pleasant than unpleasant words in the two groups of participants. Finally, our findings also point to the fact that, for an interaction between grammaticality and emotionality to emerge at the neural level, two conditions are required: the participants must show a positive dominance profile and the selected emotional words must be unpleasant.

In short, the answers to the questions initially formulated would be: (a) yes, if the right circumstances are given, one can obtain a significant

Table 1. Results of the main effects in each time window for the whole sample and for each dominance group in the NPs experiment with unpleasant vs. neutral adjectives

Component / Time Window	Whole Sample	Negative Dominance Group	Positive Dominance Group
N100 (80–130 ms)	Emo.* (unpleasant > neutral)	Emo. (unpleasant > neutral)	Emo. (unpleasant > neutral) Gram. (mismatch < match)
EPN (200–300 ms)	----	----	----
LAN (300–450 ms)	Gram. (mismatch > match) Gram. x Emo (neutral mismatch = neutral match; unpleasant mismatch > unpleasant match)	Gram. (mismatch > match)	Emo. (unpleasant > neutral) Gram x Emo (neutral mismatch < neutral match; unpleasant mismatch = unpleasant match)
N400 (300–450 ms)	----	----	Emo. (unpleasant > neutral)
P600 (500–800 ms)	Gram. (mismatch > match)	----	Gram. (mismatch > match)
RTs	Gram. (mismatch < match)	Emo. (unpleasant > neutral)	Emo. (unpleasant < neutral)

Note. Emo. = Emotionality; Gram. = Grammaticality; *marginally significant.

interaction between grammaticality and emotion; (b) no, pleasant and unpleasant words do not yield similar effects, since only unpleasant words were shown to impact gender agreement processing as evidenced in the LAN time window; (c) no, not everybody is affected by emotionality in the same way when performing grammatical tasks. For this reason, it is possible that the discrepancy between the findings of the initial studies is

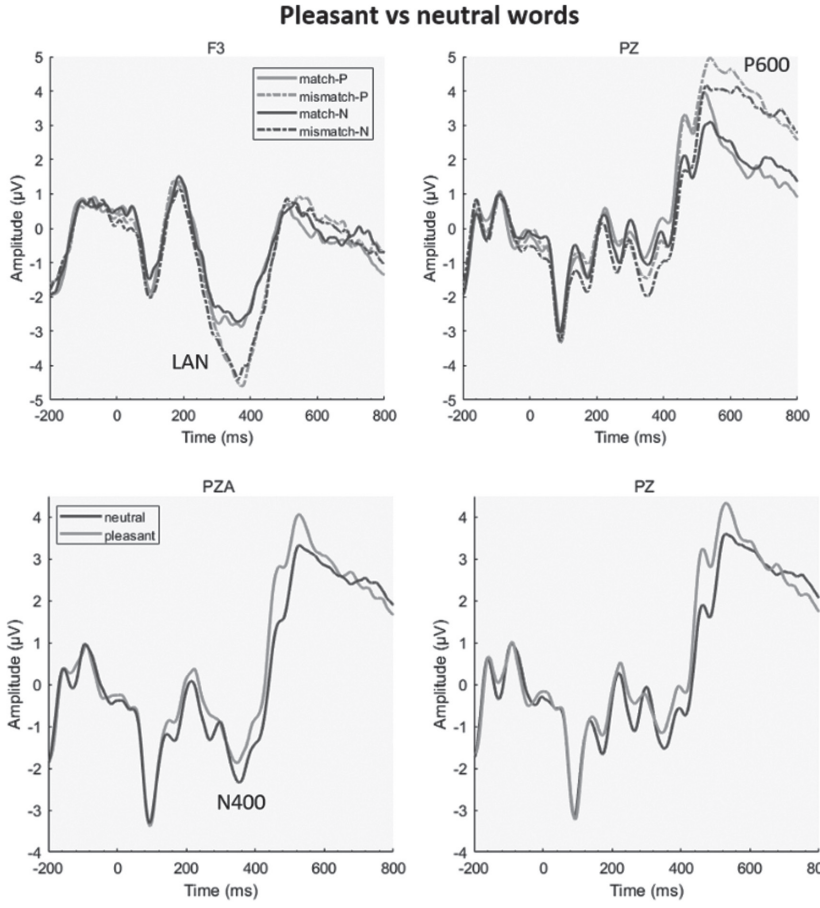

Figure 10. Experiments with noun phrases: Grand mean averaged ERP waveforms for match and mismatch conditions elicited by pleasant (green line) and neutral (grey line) adjectives at typical electrode positions for the LAN (F3), N400 (PZA) and P600 time windows (PZ).

due to the fact that they jointly analysed groups of participants who process not only emotional information but also grammatical information in different ways. Therefore, future research should be carried out without losing sight of individual differences.

Table 2. Results of the main effects in each time window for the whole sample and for each dominance group in the NPs experiment with pleasant vs. neutral adjectives

Component / Time window	Whole Sample	Negative Dominance Group	Positive Dominance Group
N100 (80–130 ms)	----	Gram. (mismatch > match)	----
EPN (200–300 ms)	----	Gram. (mismatch > match)	----
LAN (300–450 ms)	Gram. (mismatch > match)	Gram. (mismatch > match)	----
N400 (300–450 ms)	Emo.* (pleasant < neutral)	Emo.* (pleasant < neutral)	Emo.* (pleasant < neutral)
P600 (500–800 ms)	Gram. (mismatch > match)	----	Gram. (mismatch > match) Emo.* (LPC; pleasant > neutral)
RTs	Gram. (mismatch < match) Emo. (pleasant < neutral)	Gram. (mismatch < match) Emo. (pleasant < neutral)	Gram. (mismatch < match) Emo. (pleasant < neutral)

Note. Emo. = Emotionality; Gram. = Grammaticality; *marginally significant.

4. Discussion

The focus of the research described in this work is the possible influence of the emotional connotation of words on syntactic and morphosyntactic processing. In a first series of studies, we addressed this question using ambiguous relative clauses. Until that moment, most research had shown that in Spanish there is a structural preference for attaching the RC to the first noun phrase of a complex NP. Thus, in the famous sentence, *Someone*

shot the servant of the actress who was on the balcony, Spanish speakers tend to understand that it is the servant, and not the actress, who is on the balcony (but see, Aguilar et al., 2021). Our hypothesis was that, to the extent that we found that the placement of an emotional word in NP2 induces the change of the high-attachment preference towards a low attachment one, we would be demonstrating that a new unpublished variable is capable of interfering in the processing of syntactic structure, contrary to Fodor's postulates, especially if that happens early in the time record. Our results showed that there may be effects of emotionality in the disambiguation of the RC, but that these tend to weaken or disappear the more online the measure used is. This result fits perfectly with models that maintain that syntactic processing is both autonomous and encapsulated. (Fodor, 1983, 2000), but more research in this area would be necessary to draw reliable conclusions.

Regarding the studies on agreement, our findings confirm that the LAN and P600 waves are good indicators of the processing of morphosyntactic anomalies, regardless of the linguistic unit tested (phrase, clause, etc.) and of the emotionality of the words. They also reveal that the LAN / P600 biphasic pattern, considered a given until very recently (at least in rich inflection languages), might not be the rule but the exception, in line with the Tanner studies (Tanner et al., 2014; Tanner, 2019). It is therefore very relevant to take into account individual differences in grammatical processing, as this can have important implications for the learning and teaching of languages, for example. Our studies clearly show that *participants' brains behave differently*, since each group processed not only grammaticality but also emotionality in a different manner.

Additionally, our work highlights the need for proper control and maximum matching of materials to make reliable comparisons across studies. Likewise, it calls for a complete analysis of the processing course, from the first time-windows to the behavioural response, in order to arrive at a comprehensive vision of how, when and what is affected by the emotionality of words during grammatical processing. In this sense, the set of experiments carried out has allowed us to establish some conclusions, although these are limited to the use of emotional adjectives with a moderate level of arousal. The effects found thus reveal significant interactions between

the dominance profile of participants and the affective valence of words. For example, higher LAN / N400 amplitudes were obtained in the positivity profile group when processing gender agreement errors in unpleasant words. Instead, in the presence of pleasant words, reduced N400 amplitudes were obtained in the negativity profile group, without any influence of emotionality on morphosyntactic processing in this group across studies.

Before concluding, we would like to highlight a few points. First, individual differences in grammatical processing arise even in the absence of emotional words and even during the initial moments of processing (as evidenced by a control experiment also conducted in our lab, Padrón et al., submitted). Second, emotional processing also varies, but not only as a function of the dominance profile of the participants, but also of the experimental conditions, in the sense that the temporal prioritization of emotional vs. grammatical cues seems to depend on affective valence and on the level of arousal of the words used. Thus, in the initial studies, no early effects of word emotionality were found. However, in our experiment with NPs whose adjectives were unpleasant, such effects did emerge, probably because these words captured the participants' attention more (see Vieitez et al. 2021, for neural correlates of unpleasant adjectives with different levels of arousal; recall that unlike the words used by Hinojosa et al. (2014), which had a high level of arousal, ours had moderate arousal). Preliminary data of an ongoing experiment in our lab in which we used high arousal unpleasant words seem to go in this direction. A final issue that we must not forget is that in none of our studies have we found a significant interaction of emotionality and grammaticality identical to that found by Hinojosa et al. (2014), so we will continue to insist that new studies are needed to replicate their results. Lastly, it seems that the presence of high arousal unpleasant words in the experimental list tends to harm the performance of some participants in match trials whose NPs contain neutral words (Vieitez et al. in preparation).

To sum up, our research has reached a stage where it is not only interesting to know if, when and how an interaction between grammaticality and emotionality takes place, but also to consider other aspects recently opened up by a kind of Pandora's box that augur a long trajectory of research in this field. Thus, in view of the different effects obtained in

the LAN component across similar studies, as well as the numerous effects recorded in other time windows and components (e.g. N100, EPN, N400, LPC), the role of valence and arousal needs further clarification. Likewise, latent variables behind individual differences remain unknown, hence more research is needed for properly addressing this important issue. On these lines, it is possible that the neural response underlying the performance of grammatical tasks in affective words may vary along the time course of processing in ways unforeseen so far, showing a more complex picture than expected.

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