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The role of prominence in Spanish sentence comprehension: An ERP study

Carolina A. Gattei *, Ángel Tabullo, Luis París, Alejandro J. Wainselboim

Grupo de Lingüística y Neurobiología Experimental del Lenguaje, Instituto de Ciencias Humanas, Sociales y Ambientales (INCIHUSA – CONICET), Mendoza, Argentina

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ABSTRACT

Prominence is the hierarchical relation among arguments that allows us to understand 'Who did what to whom' in a sentence. The present study aimed to provide evidence about the role of prominence information for the incremental interpretation of arguments in Spanish. We investigated the time course of neural correlates associated to the comprehension of sentences that require a reversal of argument prominence hierarchization. We also studied how the amount of available prominence information may affect the incremental build-up of verbal expectations. Results of the ERP data revealed that at the disambiguating verb region, object-initial sentences (only one argument available) elicited a centro-parietal negativity with a peak at 400 ms post-onset. Subject-initial sentences (two arguments available) yielded a broadly distributed positivity at around 650 ms. This dissociation suggests that argument interpretation may depend on their morphosyntactic features, and also on the amount of prominence information available before the verb is encountered.

1. Introduction

One of the fundamental issues of language comprehension is to understand how different types of linguistic information are integrated on-line. Special attention has been paid to the linking of syntactic (form) and semantic (meaning) information, as it is through this process that speakers understand 'who did what to whom'. As an example, consider the sentence 'Peter kicked Mary'. In order to understand who is doing what to whom, speakers need to recover the information that describes a situation where someone kicked someone else; retrieve who the participants involved in the event are and assign them a thematic role (e.g. Agent, Patient, Experiencer, Recipient). Further, these two participants need to be weighed against each other by building a hierarchical representation based on the morphosyntactic and semantic features of the constituents. This hierarchy among the arguments of a sentence has been termed *prominence* (Bornkessel & Schlesewsky, 2006). The information used in order to establish the degree of prominence of a constituent relative to another constituent comprises thematic role, morphological case marking, argument position, animacy, person and definiteness among the most salient kinds. "These prominence features are often conceptualized in terms of hierarchies that (...) rank animates over inanimates, definites over indefinites, first and second person over third and agents over patients. The higher an element's rank on the hierarchy, the more prominent it is considered to be" (see Lamers & de Swart, 2012b, p. 5). For present purposes, we define an argument's prominence status as the sum of its rankings on all accessible prominence hierarchies (Kretzschmar, Bornkessel-Schlesewsky, Staub, Roehm, & Schlesewsky, 2012).

It is a well-established fact that the linguistic features that are relevant for the computation of prominence may differ from language to language (see Bornkessel-Schlesewsky & Schlesewsky, 2009; Lamers & de Swart, 2012a for a discussion on the issue). For instance, while word order may be a relevant cue for establishing arguments' prominence in languages with little or no case marking inflection (e.g. English, Chinese) it may only be considered a last-resort strategy in languages with a rich case marking system (e.g. Finnish, Japanese, Russian). Similarly, the role of linear word order on the establishment of prominence may depend on the possibility of subject dropping in a particular language. In languages with a high proportion of dropped subjects (e.g., Turkish, Japanese, Spanish), an initial accusative argument is compatible with a canonically ordered prominence hierarchy in which the Actor (usually the nominative argument) is absent. On the contrary, in languages that do not allow dropped subjects (e.g. German), an accusative initial argument would lead to the interpretation of this constituent as the Undergoer of a

* Corresponding author at: Instituto de Ciencias Humanas, Sociales y Ambientales CCT CONICET Mendoza, Av. Ruiz Leal s/n, Parque General San Martín, Mendoza CP 5500, Argentina.

E-mail address: carolina.gattei@conicet.gov.ar (C.A. Gattei).

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non-canonically ordered prominence hierarchy. Furthermore, certain languages establish their prominence hierarchy based on the animacy of the sentence arguments. For instance, in Fore, a Papuan language, in the absence of case marking, the argument highest in the animacy hierarchy will be interpreted as the most agent-like argument. When the two arguments are equal in animacy, word order determines the interpretation, and the first noun phrase is interpreted as the most agent-like one (de Swart, 2007). In order to express the opposite meaning, additional morphological information is required.

These cross-linguistic differences have led scholars to focus their interest on how the interaction of different linguistic cues related to prominence may affect incremental processing, and to ask whether there are common neuroanatomical and neurophysiological correlates of prominence processing. EEG studies have identified several ERP components associated to the interplay between different types of syntactic and semantic information that are relevant in the computation of prominence (see Table 1 for a summary of findings on this issue and predictions for the current study). For instance, the assignment of a more prominent status to an inanimate argument has been found to elicit a centro-parietal negativity between 400 and 600 ms post onset (N400) in comparison with an animate argument (Frisch & Schlesewsky, 2001; Roehm, Schlesewsky, Bornkessel, Frisch, & Haider, 2004; Weckerly & Kutas, 1999).

The interplay between case marking and word order has also been found to elicit a fronto-central negativity with a focus to the left between approximately 300 and 500 ms post argument onset whenever an accusative argument (usually related to the Undergoer of an event) was in first position in German embedded clauses (Bornkessel, Schlesewsky, & Friederici, 2002; Rösler, Pechmann, Streb, Röder, & Hennighausen, 1998; Schlesewsky, Bornkessel, & Frisch, 2003).

Crucially for the purposes of the present work, many of these studies support the claim that prominence information is rapidly extracted in order to trigger predictions about the lexical-semantic structure of the upcoming main verb in a sentence. However, the findings offer a very complex pattern of results that depends on the type of language and the type of linguistic features studied. Evidence from German studies has shown that a mismatch between the previously computed prominence and the establishment of the lexical-semantic structure of the verb elicited either an early parietal positivity between 300 and 600 ms post onset (Bornkessel, Schlesewsky, & Friederici, 2003b), a late parietal positivity (P600; e.g., Friederici & Mecklinger, 1996; Graben, Saddy, Schlesewsky, & Kurths, 2000), or a centro-parietal negativity between 350 and 550 ms (N400; Bornkessel, McElree, Schlesewsky, & Friederici, 2004; Leuckefeld, 2005, for the auditory modality) depending on the manipulation of morphological case ambiguity, morphological case, word order and verb type. Manipulation of word order and verb type in Italian, an SVO language that also relies on morphological case marking to achieve sentence interpretation, but which, unlike German, allows subject dropping, elicited a broadly distributed positivity between 650 and 800 ms (P600: Dröge, Maffongelli, & Bornkessel-Schlesewsky, 2014). Evidence from Chinese, an SVO language whose arguments have no case marking morphology, revealed that the interaction between animacy and argument interpretation elicited an anterior negativity when two ambiguous arguments preceded the verb (Wang, Schlesewsky, Philipp, & Bornkessel-Schlesewsky, 2012), while it has been shown to have no effect in Chinese sentences involving only a single ambiguous argument (Wang, Schlesewsky, Bickel, & Bornkessel-Schlesewsky, 2009). Further evidence from this language has shown that animacy, word order and pragmatic restrictions imposed by a particular construction (as in adversative passives, which are used to show that the first argument is negatively affected by the event that is being described – i.e. bears an experiencer role) engendered an N400 component whenever an inanimate actor argument was presented in second position, and when an inanimate undergoer argument was presented in first position in passive sentences. These findings show that the N400 is sensitive to the interaction between thematic interpretation and language-specific pragmatic principles (Philipp, Bornkessel-Schlesewsky, Bisang, & Schlesewsky, 2008, and see Li, Bates, & MacWhinney, 1993 for previous behavioural results on this interaction).

The present study aims at providing evidence about the role of prominence information for the incremental interpretation of arguments in Spanish, a language that has been briefly investigated in this regard. More precisely, we will investigate the time course of neural correlates associated to the comprehension of sentences that require a reversal of argument prominence hierarchization. In the following section, we will describe the linguistic characteristics of Spanish relevant to the computation of prominence.

1.1. Argument hierarchization in Spanish

Argument prominence scales in Spanish result from the interaction of many factors: word order, verb type and case marking are three of the most relevant ones. Consider sentences in (1).

(1)					
a.	Juan	le	grita	a	María.
	John_{NOM}	clit_{DAT}	yells	to	Mary_{DAT}
b.	A	María	le	grita	Juan.
	To	Mary_{DAT}	clit_{DAT}	yells	John_{NOM}

The verb in (1) is an activity verb. Example (1.a) represents a subject-initial sentence; in contrast, in (1.b) the dative object precedes the subject. Both sentences mean '*John yells at Mary*'. Although (1.b) is a structure where the undergoer of the action of 'yelling' linearly precedes the Actor, speakers understand in both cases that it is John that yells at Mary and not the other way around through case marking (the dative pronoun 'le'), clitic doubling (co-reference between 'le' and 'María') and the preposition 'a', that functions here as particle marking indirect object.

Regarding the role of verb type in the computation of prominence, identical configurations may instantiate different semantic hierarchizations for its constituents, as shown in sentences in (2).

(2)					
a.	Juan	le	teme	a	María.
	John_{NOM}	clit_{DAT}	fears	to	Mary_{DAT}
	John fears Mary.				
b.	Juan	le	gusta	a	María.
	John_{NOM}	clit_{DAT}	likes	to	Mary_{DAT}
	Mary likes John.				

Both sentences are syntactically alike and they require a similar semantic structure. A constituent is assigned the role of Experiencer and the other one is assigned the role of Theme/Stimulus. However, in sentence (2.a) the role of Experiencer is linked to the subject of the sentence (i.e. 'Juan'), while in (2.b), the role of Experiencer is associated with the object ('María'). An important aspect of this distinction is that although sentence (2.b) follows the canonical SVO word order of the language (Contreras, 1991; Hernanz & Brucart, 1987; Ocampo, 1995; Suñer, 1982, among others), its prominence hierarchy follows a non-canonical order

Table 1
Results of previous ERP studies and predictions for current study on incremental argument interpretation according to: The language studied, the language morphosyntactic characteristics, the modality of presentation of the stimuli (written or auditory), the interaction of different linguistic types of information (Word Order, Case, Verb Type, Animacy, presentation of the argument as a full NP or a Pronoun, Argument Span, and Voice), and the onset region (Det, NP, Auxiliary or Verb). Det = Determiner, NP = noun phrase. LAN = Left Anterior Negativity. In the column "Morphological case marking", all inflectional case marking (as in German), prepositional case marking (as in Italian and Spanish) and pronominal case marking (as in the three previous languages and English) are considered.

Study	Language	Morphosyntactic characteristics of the language			Modality	Interaction of factors								Region	Effect
		Word Order Alternation	Morphological case marking	Subject-dropping		Word Order	Case	Animacy	Agreement	Full NP vs Pronoun	Verb Type	Argument Span	Voice		
Weckerly and Kutas, 1999	English	No	Yes	No	Written			■						NP	N400
Rösler et al., 1998	German	Yes	Yes	No	Written	■	■							NP /Verb	Posterior Positivity/ LAN / N400
Graben et al., 2000						■			■					Det / Verb	P600
Friederici and Mecklinger, 1996						■	■		■					Auxiliary	P600
Frisch and Schlesewsky, 2001 / Roehm et al., 2004						■	■	■			■			NP	N400
Borkessel et al., 2002						■	■								Fronto-central negativity (300-500 ms)
Schlesewsky et al., 2003						■	■			■					Broadly distributed Negativity
Bornkessel et al., 2003b						■	■				■			Verb	Early parietal positivity (300 - 600 ms)
Bornkessel et al., 2004						■	■								N400 / P600
Leuckefeld, 2005					Auditory	■	■				■			Verb	N400
Phillip et al., 2008	Chinese	Yes	No	Yes	Auditory	■		■					■	NP	N400
Wang et al, 2009 / Wang et al., 2012						■		■				■	■	Verb	No effect (1 NP prior to Verb) / Anterior Negativity (2 NPs prior to Verb)
Dröge et al., 2014	Italian	Yes	Yes	Yes	Written	■					■			Verb	N400/P600
Current Study	Spanish	Yes	Yes	Yes	Written	■					■	■		Verb	N400 or P600 depending on span

(i.e. the Theme/Stimulus precedes the more actor-like participant). Now consider a sentence like (3):

(3)

A	María	le	gusta	Juan.
To	Mary$_{\text{DAT}}$	clit$_{\text{DAT}}$	likes	John$_{\text{NOM}}$

Mary likes John.

The sentence realises a marked OVS word order. However, the order of arguments mirrors the <Experiencer, Theme> canonical order established by the lexico-semantic structure of the verb 'like', as exemplified in (4), in which 'like' is a State predicate of emotion and 'x', the left-most argument of this structure is associated to the Emoter or Experiencer, and 'y' is associated to the Target, Stimulus or Theme (Van Valin, 2005, p. 45).

(4)
like (x,y)

This mismatch between syntactic and semantic structures is a characteristic property of a particular class of verbs known as dative object–experiencer psychological verbs (thereafter ObjExp psych verbs) and will be used to test the incremental interpretation of prominence scales in the current study.

1.2. Predictions

It is relevant for our present purpose that a previous self-paced reading study in Spanish (Gattei, Dickey, Wainselboim, & París, 2015) has shown that when reading sentences like those in (1–3), subjects have higher processing difficulties if the order of arguments does not parallel the canonical order of the thematic hierarchy, independently of the verb type used in the sentences (as it occurs in sentences 1.b and 2.b). As stated in the introduction, neurophysiological studies have brought up evidence that varies depending on language-specific morphosyntactic and semantic properties. It remains unclear, though, what kind of neurophysiological components are associated with the incremental computation and revision of prominence scales in Spanish. Based on the findings from a previous study run in Italian, failure to predict the upcoming type of verb in a declarative simple sentence should elicit an N400 effect that reflects a mismatch between the prominence scales computed and the linking required by the lexical semantic structure of the verb (Dröge et al., 2014). More precisely, consider the appearance of the constituent 'Juan' in first position. Computation of prominence scales depends on the extraction of the following linguistic features: case marking (+NOM) and word order (1st Position). Accordingly, the argument is interpreted as 'Agent' and a verb that assigns this semantic role is predicted. Likewise, the features (+DAT) and (+1st Position) are extracted from the appearance of the constituent 'A Juan' in an object-initial sentence. The highest ranked thematic role that could bear these features is the role of 'Experiencer'. ObjExp psych verb is then predicted. Up to this point, Spanish and Italian are similar and similar ERP effects are thus expected. However, Spanish differs from Italian in the use of pronominal clitics that are co-referential with the dative marked object, as shown in (5).

(5)

Italian examples

a.	Piero	piace	a	Matilde.	
	Piero$_{\text{NOM}}$	appeals	to	Matilde$_{\text{DAT}}$	
	'Matilde likes Piero'				
b.	A	Piero	piace	Matilde.	
	to	Piero$_{\text{DAT}}$	appeals	Matilde$_{\text{NOM}}$	
	'Piero likes Matilde'				

Spanish examples

c.	Juan	le	gusta	a	María.
	Juan$_{\text{NOM}}$	$_{\text{DAT}}$	likes	to	María$_{\text{DAT}}$.
	'María likes Juan'				
d.	A	Juan	le	gusta	María.
	To	Juan$_{\text{DAT}}$	$_{\text{DAT}}$	likes	María$_{\text{NOM}}$

In consequence, there is a difference between subject initial and object initial sentences regarding the prominence information available before the appearance of the disambiguating verb. While subject-initial sentences count on prominence information provided by both nominative NP and the dative clitic, the dative clitic in OVS sentences replicates the information provided by the initial dative NP, as exemplified in (6).

(6)

a.	Juan	le ...
	+NOM	+DAT
	1st Argument	2nd Argument
	Agent?	Theme/Recipient?
b.	A Juan$_i$	le$_i$ ...
	+DAT	+DAT
	1st Argument	1st Argument
	Experiencer?	Experiencer?

This phenomenon will allow us to test whether prominence information span is also relevant for incremental argument interpretation in this language, and to find if thematic misanalysis has differential neurophysiological signatures according to the amount of prominence information available, as it has been shown for Chinese (Wang et al., 2009, 2012).

2. Materials and methods

The present experiment will use event-related brain potentials (ERPs) to examine the role of prominence information in Spanish sentences by varying the thematic structure of the verb. The factor Verb (activity vs. object-experiencer psych verbs) is responsible for this thematic structure variation. Moreover, the experiment involves the manipulation of word order (SVO vs. OVS). The assumption behind this operation is that the parser computes morphosyntactic information – like case and word position – to predict the kind of verb that will come along in the sentence. Furthermore, the manipulation captured by the factor Order will allow us to tease apart whether availability of further prominence information provided by the dative clitic increases expectations about the class of the upcoming verb or not. The factors Verb and Order give rise to a 2×2 design, the four conditions of which are illustrated in Table 2.

2.1. Materials

The experimental sentences for this study were constructed on the basis of two verb lists, consisting of 24 items for each type of

Table 2
Critical sentences for the current Event Related Potentials (ERP) study.

Condition	Sentence
(a) Activity Verb SVO	Juan le grita a María porque... John DAT_i yells to $Mary_i$ because... *John yells at Mary because...*
(b) Activity Verb OVS	A Juan le grita María porque... To $John_i$ DAT_i yells Mary because... *Mary yells to John because...*
(c) Object Experiencer Psych Verb SVO	Juan le gusta a María porque ... John DAT_i likes to $Mary_i$ because... *Mary likes John because...*
(d) Object Experiencer Psych Verb OVS	A Juan le gusta María porque... To $John_i$ DAT_i likes Mary because... *John likes Mary because...*

verbs. The two groups of verbs were matched in length (Psych verbs: $M = 6.8$, $SE = .31$; Activity verbs: $M = 6.3$, $SE = .25$) and Log frequency (Psych verbs $M = 4.32$, $SE = .17$; Activity verbs: $M = 4.47$, $SE = .11$) according to the LEXESP database (Davis & Perea, 2005). An independent-samples *T*-test showed no significant differences between groups: Length: $t(46) = -1.35$, $p > .05$; Log Frequency $t(46) = .71$, $p > .05$.

Verbs were placed in semantically reversible sentence frames that consisted of 96 pairs of proper nouns matched for length and frequency and counterbalanced for gender. Data of names' approximate frequency was collected by conducting an advanced Google search in the domain of the site Facebook from Argentina. Table 3 shows the mean, standard errors, *t*-scores and *p*-values for frequency and length of the two groups of names.

Names position of each pair of names was alternated so that 192 blocks of the four conditions were formed. The total number of 768 experimental sentences thus constructed was divided into four lists of 192 sentences (48 per condition) so that participants would see all lexical material consisting of the verb and the two proper nouns twice. Names were also distributed between lists so that each participant would see one pair of names alternatively framing a psych verb or an activity verb. This manipulation was intended to avoid that one pair of names was associated to one particular type of verb. Finally, 192 additional Prepositional Phrase (PP), Adverbial Phrase (AdvP) or Complementizer Phrase (CP) were added at the end of each block of sentences. These additional phrases could be attached to both NPs when placed after the verb, and they were semantically neutral, so that they did not facilitate any semantic interpretation rather than the one provided by the role assignment required by the verb.

In addition, a set of three practice trials and 130 filler sentences were created. These sentences contained different syntactic complexity and length than the critical trials, so that participants would not be aware of the aim of the experiment. A complete set of critical sentences may be found in the Supplemental Material A section. Supplemental Material B section shows the complete list of proper names used to frame the sentences.

Table 3
Mean values, standard errors, *t*-scores and *p*-values for frequency and length of the two groups of nouns chosen for the current experiment.

	Group	*N*	Mean	S.E.	*t*	*p*-value
Frequency	NP1	96	9.57	0.083	0.02	0.97
	NP2	96	9.56	0.082		
Length	NP1	96	6.22	0.11	1.10	0.27
	NP2	96	6.03	0.12		

Finally, one question for each practice item, critical trial and 30 of the filler sentences were prepared to test comprehension. The questions were formulated in such way that the participants had to judge whether it correctly described the content of the preceding experimental sentence or not. Half of the questions required the answer "yes" and half of them required the answer "no". In the case of critical items, half of the questions involved the subject of the sentence and half of them asked about the object.

2.2. Participants

Twenty-four native speakers of Argentinean Spanish (16 females) participated on the experiment. Subjects ranged in age from 18 to 27 years old ($M = 22.2$ years old). All subjects were right-handed and had no history of prior neurological disease, drug or alcohol abuse, psychiatric disorders, developmental speech/ language disorders, or learning disabilities. All participants had normal or corrected to normal vision. All of them provided written consent prior to the study. Seventeen of the participants entered the final data analysis, the remaining seven having been excluded on the basis of EEG-artefacts and/or insufficient accuracy in the comprehension task (an error rate higher than 40% in any one condition).

2.3. Procedure

The experiment was carried out in an acoustically and electrically isolated room. Subjects were instructed to read sentences from a computer screen and to answer the comprehension question that would appear afterwards by pressing the right Ctrl key for 'yes' and the left Ctrl key for 'no' as fast as they could. Each sentence was presented in a word-by-word manner in the centre of a computer screen. The presentation of a sentence was preceded by ' +' sign, which appeared for 450 ms followed by a pause of 250 ms. Single word segments were presented for 450 ms with an interstimulus interval of 250 ms. The presentation of a sentence was followed by an 1000 ms pause, after which the comprehension question was presented. Participants were given maximally 2000 ms to decide what the correct answer for the question was. After an answer had been given, there was a 1000 ms pause before the '+' sign indicated the beginning of the next sentence. Participants were asked to avoid movements and to only blink their eyes between the appearance of the comprehension question and the presentation of the next sentence. Participants were exposed to 322 sentences (192 critical items + 130 fillers) in two blocks of 80 trials and two blocks of 81 trials, with three short intervals between them. All experimental tasks were programmed using the PyE×PsiN platform, a Python module made for writing psychological experiments developed by Sergio Vernis (http://pyexpsin.sourceforge.net/). Presentation of critical items and fillers was randomised for each participant. Experimental sessions lasted between 90 and 120 min depending on the amount of time that participants took between blocks in order to rest.

2.4. EEG recording

Electroencephalographic activity was recorded from 30 cap-mounted tin electrodes (international 10/20 system, biauricular reference, Electro-Cap International Inc.). Electrode impedances were kept under 10 kΩ. EEG was sampled at 256 Hz, and bandpass filtered at 0.5–30 Hz. ERPs were time-locked to the onset of the verb and the following word. Epoch length was 1000 ms, with a 200 ms pre-stimulus interval as baseline. EEG signal processing and ERP analysis were carried out with EEGLAB software (Delorme & Makeig, 2004). Ocular artefacts were removed from data by means of ICA-based artefact correction, applying the

ADJUST algorithm (Mognon, Jovicich, Bruzzone, & Buiatti, 2011). Epochs containing other kinds of artefacts were detected by visual inspection and excluded from the analysis (less than 10% of the trials, evenly distributed across conditions).

2.5. Data analysis

For the behavioural data, error rates and response times (RTs) were calculated for each condition. Incorrectly answered trials were excluded from the response time analysis. Raw response times were transformed to log-normal values, as raw RTs may lead to incorrect conclusions due to the non-normality of distribution of its residuals (Baayen & Milin, 2010). For the sake of a better understanding of the data, reading times are reported in milliseconds.

For the statistical analysis of the ERP data, repeated measures analyses of variance (ANOVAs) were calculated for mean amplitude values per time window per condition. Mean voltage was calculated for each time window of interest. Time windows were chosen according to the latency ranges of the N400 component and the P3/P600 components typically reported in cognitive ERP studies (Bornkessel, Schlesewsky, & Friederici, 2003a; Erdocia, Laka, Mestres-Misse, & Rodriguez-Fornells, 2009; Hagoort, Brown, & Groothusen, 1993; Osterhout, Holcomb, & Swinney, 1994; Van Herten, Kolk, & Chwilla, 2005, etc.). For the disambiguating region of the verb, mean voltage was analysed through a $2 \times 2 \times 2 \times 3$ repeated measures analyses of variance (ANOVA) with the following within-subject factors: Verb (Activity vs. ObjExp) $\times$ Word Order (SVO vs. OVS) $\times$ Hemisphere (Left vs. Right) $\times$ Region (Anterior, Central and Posterior). Midline electrodes were analysed similarly, using the within-subject factor of Electrode. Due to differences in structure in the second argument (for OVS sentences the ROI consisted of a proper noun and for SVO sentences it consisted of preposition 'a'), only similar structures were compared for statistical analysis, and Word Order was dismissed as a factor, resulting in a $2 \times 2 \times 3$ repeated measures ANOVA. Crossing the two factors for the lateral electrodes (Hemisphere $\times$ Region) resulted in the following six regions of interest (ROIs): left-anterior (F7, F3, FC5 and FP1); right-anterior (F8, F5, FC6 and FP2); left-central (FC1, C3, CP5 and T7); right-central (FC2, C4, CP6 and T8), left-posterior (CP1, P7, P3 and O1), right-posterior (CP2, P4, P8, O2). For the analysis of midline electrodes, the factor Electrode (Elec) with the six electrodes FPZ, AFZ, FZ, CZ PZ and POZ as levels was taken into account. Time windows were chosen on the basis of previous studies and visual inspection of the data. The statistical analysis was carried out in a hierarchical manner, i.e., only significant effects and interactions ($p < .05$) were resolved. Additionally, no main effects of or interactions between topographical factors will be reported. In order to avoid excessive Type I errors due to violations of sphericity, Greenhouse-Geisser correction was applied when the analysis involved factors with more than one degree of freedom in the numerator (Geisser & Greenhouse, 1959). Moreover, post hoc comparison *p*-values were Bonferroni adjusted (Keppel, 1991).

3. Results

3.1. Behavioural data

With regard to error rates, a repeated measures ANOVA revealed a main effect of Verb Type, with sentences with psych verbs giving rise to a higher error rate (18.81%) than their activity verbs counterparts (14.27%) ($F(1,16) = 11.11$, $p < .01$). The analysis also showed an interaction between Word Order and Verb Type ($F(1,16) = 12.29$, $p < 0.01$). Resolving this interaction revealed that Word Order had a significant influence on conditions with both activity verbs and with psych verbs (Act: $F(1,16) = 17.28$, $p < 0.01$; ObjExp: $F(1,16) = 6.36$, $p < 0.05$). Fig. 1A shows the percentage of correct answers per condition.

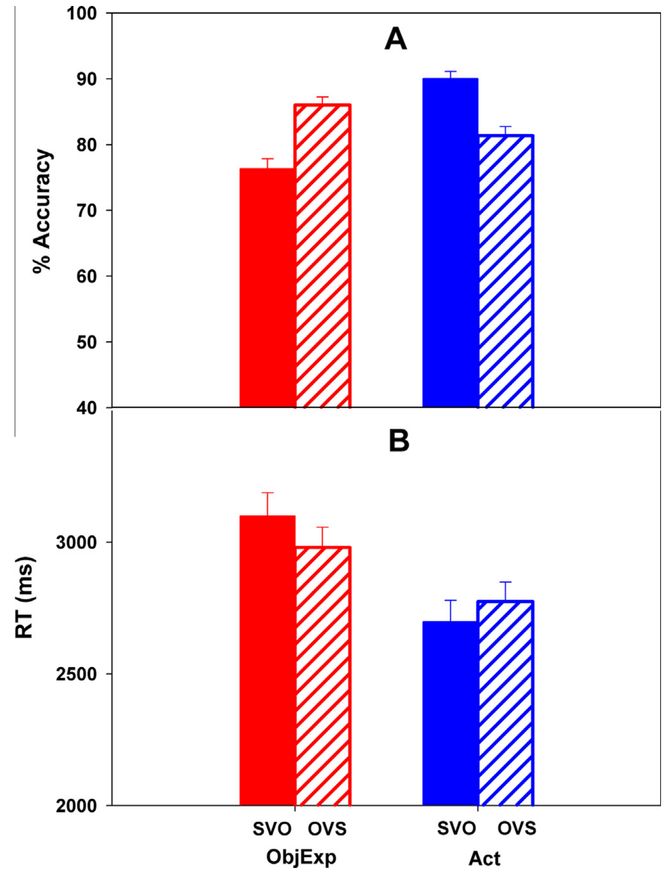

Fig. 1. Mean percentage of correct answers (±SE) (A) and mean RTs (±SE) (B) for the sentence comprehension task in the current ERP experiment according to condition.

The analysis of the response times also revealed a main effect of Verb Type ($F(1,16) = 14.3$, $p < .01$). Response times were longer for questions about sentences with psych verbs ($M = 3039$ ms; $SE = 83$ ms) than for questions about sentences with activity verbs ($M = 2736$ ms; $SE = 77$ ms). Fig. 1B shows mean response time for each condition.

3.2. ERP data

3.2.1. Verb region

Fig. 2 shows grand averages for nominative-initial sentences (A) and object-initial sentences (B) at the position of the disambiguating verb at selected electrodes. Visual inspection and Grand Average waveforms of SVO sentences revealed a positivity with a maximum around 650 ms for sentences with psych verbs. Topographical distribution of this positivity is more prominent in left posterior electrodes. Visual inspection of OVS sentences revealed a negativity with a peak at approximately 400 ms after the onset of the critical verb for sentences with activity verbs. The negativity was more prominent at central and posterior sites, with a latency and topography similar to that of an N400 (see Kutas & Federmeier, 2011; Kutas, Van Petten, & Kluender, 2006, chap. 17; Lau, Phillips, & Poeppel, 2008 for reviews). Two time windows were chosen for the analysis of these effects: 400–550 ms for the negativity and 600–750 ms for the positivity.

400–550 ms time window. The global analysis of the lateral electrodes revealed that the difference between both word orders was

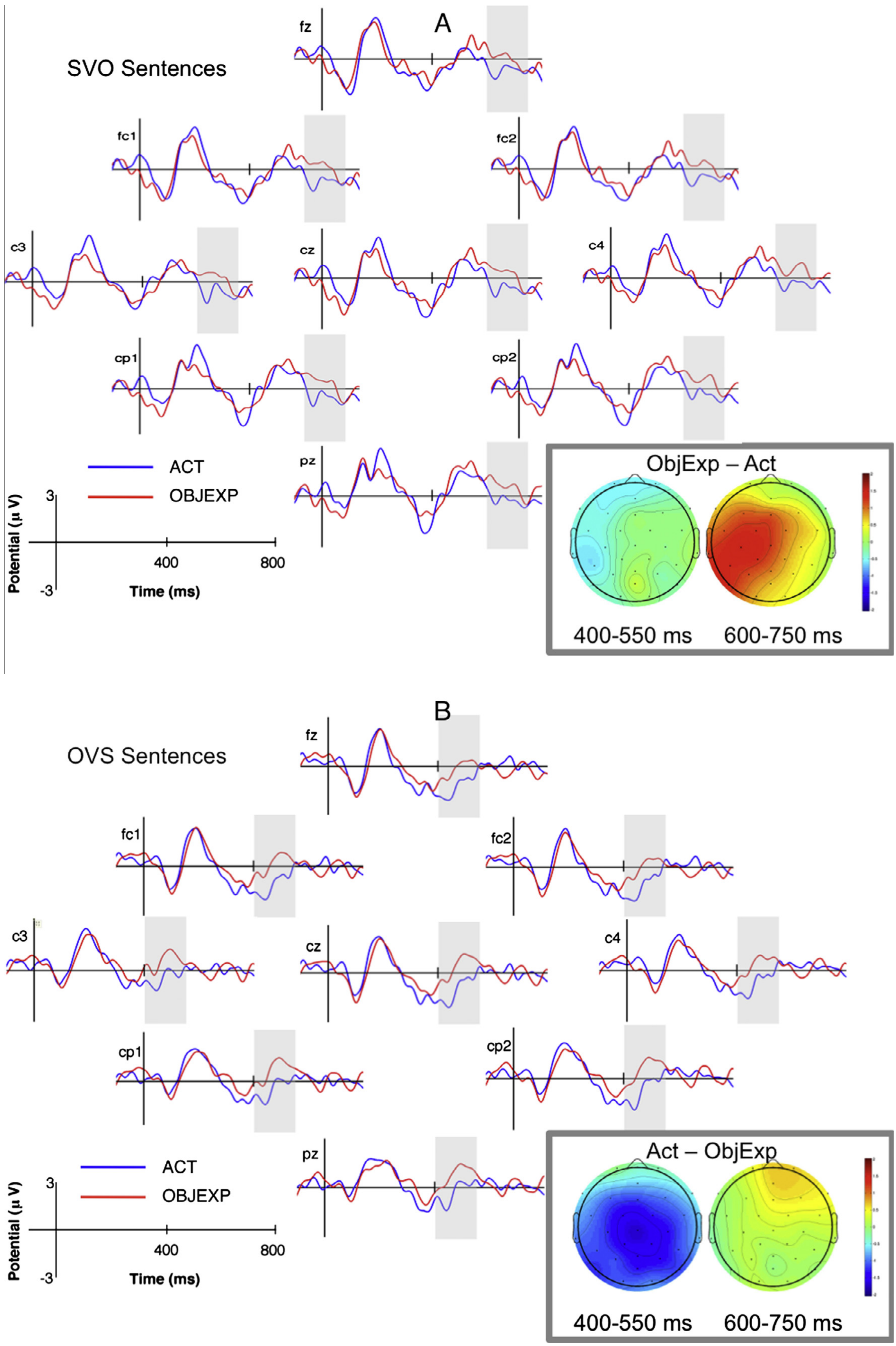

Fig. 2. Grand average ($N = 17$) ERPs at selected electrodes at the position of the verb (onset at the vertical bar) for activity (blue) vs. object-experiencer psych verbs (red) in SVO (A) and OVS (B) sentences. Negative is plotted downwards. The grey area shows the time windows in which there were significant differences in mean voltage. The bottom-right section of the figure shows the difference wave scalp topographies for the time windows analysed. ACT = Activity, OBJEXP = Object Experiencer Psych Verb.

close to significant. On average, mean voltage was higher for object-initial sentences than for subject-initial sentences, $F(1,16) = 3.50$, $p = .08$. The analysis also showed a significant interaction between Verb Type and Word Order, $F(1,16) = 8.20$, $p = .01$. Resolving this interaction revealed that for object-initial sentences, mean voltage of sentences with Activity verbs and ObjExp psych verbs was significantly different, $F(1,16) = 6.18$, $p < .04$, whereas no difference was found between both types of verbs in subject-initial sentences, $F(1,16) = 1.14$, $p = .6$. Planned comparisons also showed that this difference was significant for electrodes at all regions (Left-Ant: $F(1,16) = 5.74$, $p < .04$; Left-Cen: $F(1,16) = 5.00$, $p < .04$; Left-Post: $F(1,16) = 5.27$, $p < .03$; Right-Ant: $F(1,16) = 5.93$, $p < .03$; Right-Cen: $F(1,16) = 4.92$, $p < .05$; Right-Post: $F(1,16) = 5.56$, $p < .04$).

Analysis of the midline electrodes showed a main effect of Word Order, $F(1,16) = 4.93$, $p = .04$, and interactions between Verb Type and Word Order, $F(1,16) = 4.99$, $p = .04$, and between Word Order and Electrode, $F(5,80) = 5.25$, $p = .02$. Resolving the interaction between Verb Type and Word Order showed that the difference between sentences with activity verbs and psych verbs was significant for OVS sentences but not for their SVO counterparts (OVS: $F(1,16) = 7.23$, $p = .03$; SVO: $F(1,16) = .1$, $p = 1$). Planned comparisons for each of the midline electrodes revealed that this interaction was significant at all anterior and central electrodes (FPZ: $F(1,16) = 5.71$, $p < .03$; AFZ: $F(1,16) = 5.02$, $p < .04$; FZ: $F(1,16) = 4.71$, $p < .05$; CZ: $F(1,16) = 4.98$, $p < .05$).

600–750 ms time window. Statistical analysis of lateral electrodes revealed significant interactions of Verb Type × Word Order, Verb Type × Region, Word Order × Hemisphere (Verb × WO: $F(1,16) = 5.56$, $p = .03$; Verb × Region: $F(2,32) = 7.02$, $p < .01$; WO × Hem: $F(1,16) = 6.9$, $p = .02$). Resolving these interactions showed that for subject-initial sentences, mean voltage was significantly higher for sentences with psych verbs than for sentences with activity verbs ($F(1,16) = 7.92$, $p < .03$). Although mean voltage of OVS sentences with activity verbs was higher than the mean voltage of sentences with psych verbs, this difference was not significant ($F(1,16) = 1.27$, $p = .55$). Planned comparisons showed that the difference between psych verbs and activity verbs in SVO conditions was significant at left-anterior, left-central, left-posterior, and right-central electrodes (Left-Ant $F(1,16) = 5.82$, $p < .03$; Left-Cen: $F(1,16) = 11.83$, $p < .01$; Left-Post: $F(1,16) = 8.11$, $p < .02$; Right-Cen: $F(1,16) = 5.49$, $p < .04$).

Analyses of the midline electrodes revealed significant interactions of Verb Type × Word Order ($F(1,16) = 6.54$, $p < .03$), and Verb Type × Electrode ($F(5,80) = 4.23$, $p < .03$). The interaction of Word Order × Electrode was close to significant, $F(5,80) = 3.26$, $p = .06$. Resolving the Verb Type × Word Order interaction revealed that difference mean voltage is significant for SVO conditions but not for OVS sentences (SVO: $F(1,16) = 7.46$, $p < .03$; OVS: $F(1,16) = 1.8$, $p = .4$). Planned comparisons revealed that in SVO sentences, mean voltage was significantly higher for sentences with psych verbs than for sentences with activity verbs at electrodes FZ ($F(1,16) = 8.48$, $p = .01$), CZ ($F(1,16) = 9.69$, $p = .02$), and PZ ($F(1,16) = 7.25$, $p = .01$). This difference was close to significant at electrode POZ ($F(1,16) = 3.65$, $p = .07$).

3.2.2. NP2 region

Fig. 3 shows grand averages for nominative-initial (A) and dative-initial (B) structures at the position of the second noun phrase at selected electrodes. Visual inspection revealed different patterns for subject-initial and object-initial sentences. Subject-initial sentences show a widely distributed positivity with a peak at around 550 ms for sentences with psych verbs vs. sentences with activity verbs. Object-initial sentences showed a negativity with a peak at around 300 ms at centro-parietal electrodes for sentences with activity verbs. This negativity is followed by a positivity with a peak at approximately 350–400 ms and left-posterior distribution for sentences with activity verbs when compared to their psych verbs counterparts. Accordingly, different time windows were chosen for the analysis of these effects: for SVO sentences, we analysed the time windows between 400 and 550 ms, while for OVS sentences we selected the time windows between 200–350 ms for the negativity and 380–480 ms for the positivity.

Recall that since the second arguments of both SVO and OVS sentences are morphologically different (i.e. the object is marked with preposition 'a') analyses were performed separately for each word order and the factor Word Order was dismissed.

3.2.2.1. SVO sentences. 400–550 ms time window. The global analysis of the lateral electrodes of the subject-initial conditions revealed a significant main effect of Verb Type. On average, mean voltage was higher for conditions with psych verbs than for their activity verbs counterparts, $F(1,16) = 8.73$, $p = .009$. The interactions between Verb Type and Region and Verb Type × Region × Hemisphere were not significant (Verb × Region: $F(2,32) = 0.12$, $p = .80$; Verb × Region × Hem: $F(2,32) = 0.31$, $p = .71$). However, planned comparisons showed that lack of interaction is due to equally distributed differences in mean voltage along the scalp. On average, mean voltage of psych verbs is significantly higher than mean voltage of activity verbs at all six regions (Left-Ant: $F(1,16) = 10.21$, $p = .005$; Right-Ant: $F(1,16) = 6.29$, $p = .02$, Left-Cen: $F(1,16) = 7.74$, $p = .01$; Right-Cen: $F(1,16) = 4.82$, $p = .04$; Left-Post: $F(1,16) = 8.08$, $p = .01$, Right-Post: $F(1,16) = 5.98$, $p = .02$). Analysis of the midline electrodes revealed a main effect of Verb Type, $F(1,16) = 7.70$, $p = .01$. Difference in mean voltage between psych verbs and activity verbs was significant at electrodes CZ, and close to significant at electrodes FZ and PZ (FZ: $F(1,16) = 8.47$, $p = .06$; CZ: $F(1,16) = 9.55$, $p = .04$, PZ: $F(1,16) = 8.30$, $p = .06$).

3.2.2.2. OVS sentences. 200–350 ms time window. Analysis of the lateral electrodes of the object-initial conditions revealed no significant effect of Verb Type, $F(1,16) = 2.07$, $p = .17$. The interaction Verb × Region was not significant, $F(2,32) = 2.40$, $p = .13$. Analysis of the midline electrodes revealed no main effect of Verb Type, $F(1,16) = 2.16$, $p = .16$. No interaction between Verb Type and Electrode was found, $F(5,80) = 1.76$, $p = .20$.

380–480 ms time window. Analysis of the lateral electrodes of the object-initial conditions revealed main effects of Verb Type and Hemisphere (Verb: $F(1,16) = 4.97$, $p = .04$; Hem: $F(1,16) = 5.83$, $p = .03$). The interaction Verb × Region was also significant, $F = (2,32) = 8.67$, $p = .007$ Planned comparisons showed that the difference between activity verbs and psych verbs was significant at all four central an posterior regions, and was close to significant at left-anterior electrodes (Left-Ant: $F(1,16) = 3.41$, $p = .08$; Left-Cen: $F(1,16) = 4.59$, $p = .04$; Right-Cen: $F(1,16) = 4.65$, $p = .04$; Left-Post: $F(1,16) = 5.96$, $p = .02$; Right-Post: $F(1,16) = 7.59$, $p = .01$). Analysis of the midline electrodes revealed a main effect of Verb Type, $F(1,16) = 5.1$, $p = .04$ and an interaction between Verb Type and Electrode $F(5,80) = 6.9$, $p = .006$. Resolving this interaction showed that the difference in mean voltage between activity and psych verbs was significant at central and posterior electrodes (CZ: $F(1,16) = 4.66$, $p = .04$). PZ: $F(1,16) = 7.60$, $p = .01$, POZ: $F(1,16) = 9.39$, $p = .007$).

4. Discussion

A substantial amount of evidence has been already gathered revealing that prominence information is rapidly computed and used in order to form expectations about the lexical-semantic class of the upcoming verb before the verb of a sentence appears

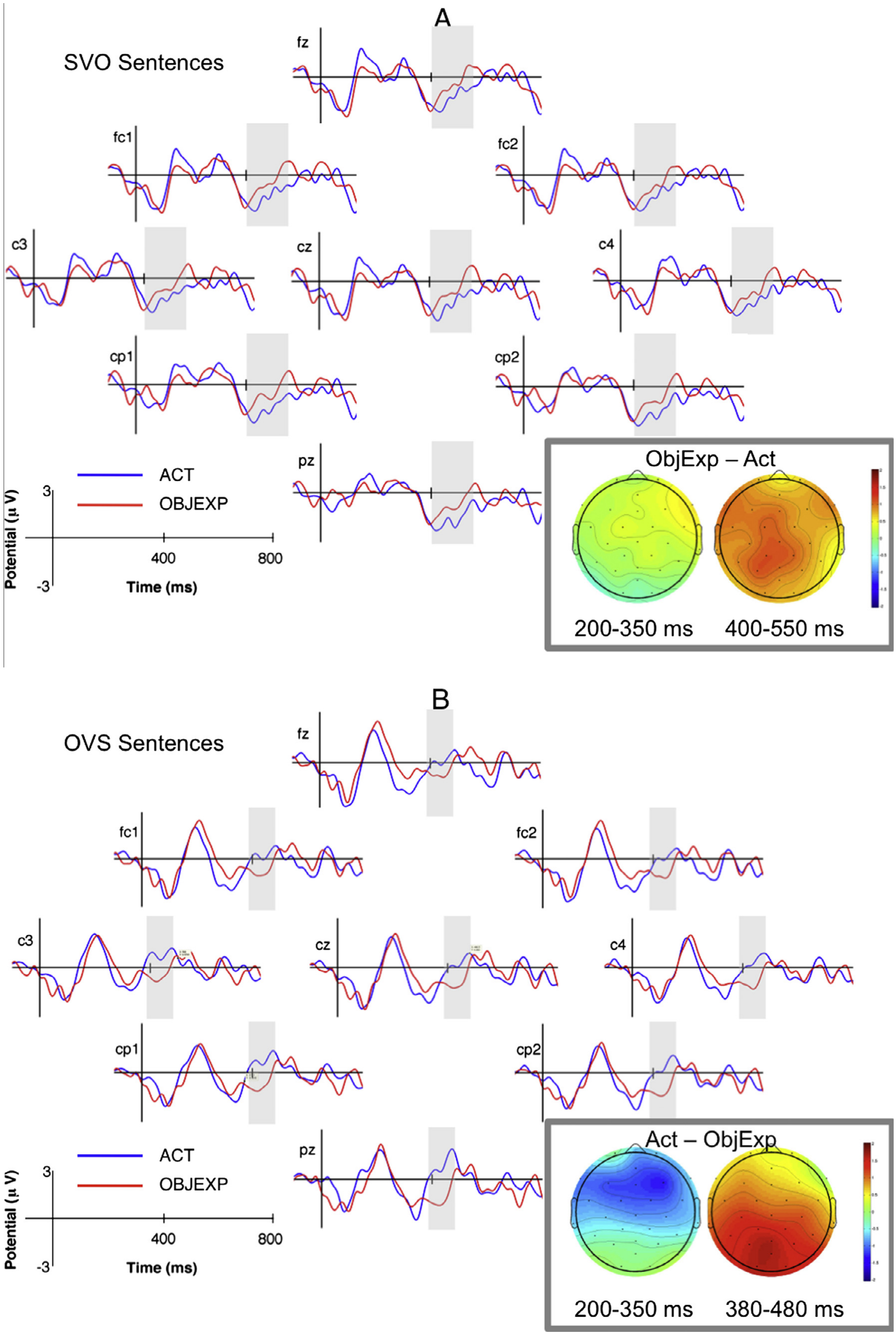

Fig. 3. Grand average ($N = 17$) ERPs at selected electrodes at the position of the following word after the verb (onset at the vertical bar) for activity (blue) vs. object-experiencer psych verbs (red) in SVO (A) and OVS (B) sentences. Negative is plotted downwards. The grey area shows the time windows in which there were significant differences in mean voltage. The bottom-right section of the figure shows the difference wave scalp topographies for the time windows analysed. ACT = Activity, OBJEXP = Object Experiencer Psych Verb.

(Bornkessel et al., 2003a; Bornkessel-Schlesewsky & Schlesewsky, 2009; Dröge et al., 2014; Kretzschmar et al., 2012; Wang et al., 2012). Although results from behavioural studies have shown uniform results (lower acceptability rates, greater reading times or higher error rates for wrongly computed prominence scales: Bornkessel et al., 2004; Gattei et al., 2015; Scheepers, Hemforth, & Konieczny, 2000), ERP and fMRI data have made evident that the pattern of the results is rather complex. More precisely, the data indicate that (a) two languages may differ in the linguistic cues that are useful for the computation of prominence but may still elicit similar ERP components; and (b) a misleading computation of prominence may elicit different ERP components or activate different brain areas depending on the language studied (see Bornkessel & Schlesewsky, 2006 for a thorough discussion and account of cross-linguistic data). We have presented an ERP experiment that examined the role of prominence information for incremental processing in Spanish. In this study, prominence information depended on the interplay between case marking and word order. The presence of a pronominal clitic prior to the verb also allowed us to test whether expectations formed through prominence information depend on the amount of available prominence information or not. Our data showed three main results: (a) in dative-initial constructions (OVS), the appearance of an activity verb gives rise to a centro-parietal negativity (between 400 and 550 ms post onset); (b) in nominative-initial constructions (SVO), the appearance of an ObjExp psych verb gives rise to a broadly distributed positivity (between 600 and 750 ms); and (c) the appearance of the second noun phrase elicits a left-posterior positivity (between 400 and 550 ms) when the order of the constituents in the sentence does not mirror the 'most prominent > least prominent' hierarchy order. In the following, we will turn to discuss each of these findings in relation to our initial question about the temporal course of prominence information parsing. Finally, we will relate the present data to cross-linguistic evidence found on the same issue.

The present study showed that, as predicted, the appearance of a verb that required the revision of the previously computed prominence scales elicited a centro-parietal negativity (N400) in object-initial sentences. However, in subject-initial sentences, the appearance of an unexpected verb elicited a broadly distributed positivity (P600). Recall that subject-initial sentences differ from their object-initial counterparts in one main aspect: Spanish dative-marked object constituents require the use of a pronominal clitic prior to the verb. Crucially for our study, during incremental parsing, the use of a dative clitic may either double the prominence information provided by the overt object (as in OVS sentences), or may provide additional information about the case (and hence the prominence status) of the second argument of the sentence (like in SVO sentences). In consequence, it is possible that the difference in available prominence information modulates the expectations about the type of verb that will appear and elicit different neural correlates for sentences with different word order. Evidence from two studies performed in Chinese has shown that manipulation of the span of constituents prior to the verb – one or two constituents – would elicit an N400-like or an anterior negativity, respectively (Wang et al., 2012). The authors showed that when only one constituent is present, comprehenders engage on a subject-first parsing strategy. However, when two constituents are presented prior to the verb, the parser uses animacy as a cue for predicting the class of the upcoming verb, giving rise to a different electrophysiological component. Our results show that in Spanish, arguments span modulates the neural correlates related to the semantic interpretation of arguments as well.

It is yet unclear whether both the N400 and P600 elicited respond to the re-evaluation of the prominence scales previously computed when reading one or two constituents – as in OVS and SVO sentences respectively – or if the N400 is also related to other parsing processes. Previous studies have shown that if the prior context leads to the expectation of a certain lexical item and this prediction is not borne out, this typically yields an N400 (e.g., DeLong, Urbach, & Kutas, 2005; Federmeier & Kutas, 1999; Kutas & Hillyard, 1984, and see Frank, Otten, Galli, & Vigliocco, 2015). Since the dative object experiencer class only contains a small number of verbs, we believe that an initial dative may impose a stronger degree of lexical constraint on the following verb than an initial nominative constituent, and that this could have affected our ERP results. In order to test whether the N400 in this experiment depended not only on thematic hierarchization but on lexical constraints as well, we conducted a completion task that would give us an estimate of the lexical and thematic predictability of both nominative and dative-initial contexts. This task will be presented in the following section.

Finally, the appearance of the second noun phrase elicited a left posterior positivity at approximately 400–550 ms whenever the word order of the sentence did not match the more-to-less prominent arguments order; this is, for SVO sentences with ObjExp verbs, and OVS sentences with Activity verbs. This outcome is in line with the findings reported by Gattei et al. (2015), who found that readers took longer time to read the second argument of a sentence when the word order of the sentence did not parallel the argument's order established by the lexical-semantic structure of the verb. It is unclear, though, whether the positivity found at this region is exclusively related to the computation of prominence since once the verb is encountered, readers already have all available information to confirm or reinterpret the prominence scale of the previous arguments. A possible explanation that accounts for this effect is related to the computation of information structure. It has been shown that the assignment of focus during silent reading and accent placement play an important role in the comprehension of written language. Focus is a grammatical property, signalled prosodically or syntactically, which characterises the element that is the most informationally important one in a sentence (Carlson, Dickey, Frazier, & Clifton, 2009). Evidence shows that readers do not only compute syntactic structures during silent reading but also prosodic structures (Frazier, Carlson, & Clifton, 2006; Steinhauer & Friederici, 2001, among others). Due to the lack of a one-to-one mapping between syntactic and prosodic structures, recovery from a syntactic misanalysis may be accompanied by the need to replace the original prosodic structure or not (Bader, 1998). Evidence from different reading studies have shown that even when prosody is not present, focus revision may take place. For instance, Bader and Meng (1999) have shown that parsing object-initial ambiguous sentences was more costly when the structural representation had to be changed from wide focus to narrow focus. Furthermore, an ERP study run in German has found a positive-going waveform between 350 and 1000 ms as a correlate of focus structural revision (Stolterfoht, Friederici, Alter, & Steube, 2007).

In Spanish, new – more salient, focused and also prosodically stressed – information typically appears late in declarative sentences, as in sentence (7), in which Maria bears focus.

(7)	Juan	le	grita	a	MARIA.
	'John yells AT MARY'				

However, syntactic manipulation may place focus at the beginning of the sentence, as it occurs in (8).

(8)	A	MARIA	le	grita	Juan.
	'It is AT MARY that John yells at.'				

In the case of our study, it is possible that after the verb is read, implicit prosodic and informational structure is either confirmed – as it would occur when reading the second NP of sentence (7) – or revised, as it may occur in sentence (8). In the latter sentence, the appearance of the activity verb leads participants to assign contrastive focus to the first NP (i.e. 'María'), thus resulting in no expectations about new information coming. This is also reinforced by the possibility of subject dropping in this language. Since the verb inflection already contains person and number information, an overt subject becomes redundant unless it is informationally relevant. The appearance of the second NP (i.e. 'Juan') results in a conflict between the saliency of both arguments and leads to the revision of the prediction of no post-verbal argument. Although this hypothesis needs further investigation, it supports previous results that show that the processing pattern for a focused constituent elicits a parietal positivity (280–480 ms) post onset of the focused phrase (Bornkessel et al., 2003b). This positivity has been interpreted as a general marker of focus integration, a process that appears to briefly supersede sentence-internal requirements. In the current experiment, this focus marker appears in both conditions in which there is a conflict between a syntactically focused constituent, and the information provided by a new, not redundant constituent (1.b. and 2.b. in Section 1).

As it has been used up to date, the notion of prominence does not include the topic-focus distinction as one of the ranking scales. In psycholinguistics, prominence is a device that integrates different types of information. In particular, it has been devoted to account for differences in processing sentences based on syntax–semantics interface properties. However, the incorporation of information structure seems like a feasible further enrichment of any processing model that resorts to the concept of prominence. First, linguistic theories assume that any sentence comprises the integration of syntax and semantics and pragmatic information (*inter alia* Van Valin, 2005; Zubizarreta, 1998). Second, the topic and focus distinction resorts to prominence to highlight one argument over the others (Lambrecht, 1994). It is a matter of future research to identify the effects of the interaction among word order, verb class and information structure during sentence processing.

5. Experiment 2: Sentence completion task

Experiment 2 was run in order to test whether sentences with initial dative-marked constituents impose a stronger degree of lexical constraint on the following verb than an initial nominative constituent, and if this could have affected our ERP results at the verb region. Therefore, we conducted a completion task in order to test whether the N400 at this region depended on both thematic hierarchization and lexical constraints. Results would give us an estimate of the lexical and thematic predictability of both nominative and dative-initial contexts.

5.1. Methods

5.1.1. Participants

184 Spanish speakers from Argentina (131 females) performed a sentence completion task through the internet-based platform Ibex Farm (developed by Alex Drummond, McGill University, available at http://spellout.net/ibexfarm). Subjects ranged in age from 18 to 61 years old ($M = 27.5$ years old). None of the subjects had a history of prior neurological disease, drug or alcohol abuse, psychiatric disorders, developmental speech/language disorders, or learning disabilities. All participants had normal or corrected to normal vision. All of them provided written consent prior to the study.

5.1.2. Materials and procedure

Critical items started with either a nominative phrase or a dative phrase. Both phrases were followed by the dative clitic, 'le' so that participants had to complete with a verb mandatorily. For the nominative and dative phrases, we only used proper names in order to exclude effects due to differences in animacy or definiteness. Two proper names were selected from the ERP experiment, one masculine and one feminine. Two versions (one nominative and one dative) for each name were included, but each participant only saw one version of each name, and gender was counterbalanced so that if they had seen a nominative feminine phrase, they saw a dative masculine phrase. In total, participants saw one item beginning with a nominative phrase and one beginning with a dative phrase (i.e., 'Silvia le ________' (nominative) or 'A Silvia le _________' (dative)) respectively. Thirty filler sentences with different length and syntactic complexity were included in the task as well, in order to avoid that participants guessed the real purpose of the task. Participants were requested to complete the beginning of the sentence as fast as possible with the first phrase that would come to their mind. They were also instructed to construct complete meaningful sentences. Order of presentation was randomized individually for each subject. Responses were entered via the terminal keyboard into a blank text window located immediately after the displayed sentence fragment.

5.1.3. Results

Two issues were encountered with the response data that needed to be resolved before further analysis: (i) Spelling errors were corrected, and missing diacritics were replaced (not all Web browser/platform configurations support the Spanish character set). (ii) If a subject had provided the same answer for most of the items and/or filler trials, the subject was discarded. This resulted in the rejection of the data from two participants. 364 responses entered the final analysis.

In order to investigate both the lexical and thematic predictability of a verb provided the initial subject-or object initial structure, we computed the production probability of each response and we performed a qualitative analysis of the thematic structure of each response.

Following (Schwanenflugel, 1986), the production probability of each response to its associated sentence frame was computed as the number of subjects who provided that response divided by the total number of subjects who contributed at least one valid response for that item. The data shows that subject-initial phrases yielded 61 different responses. For object-initial sentences, 37 different responses were given. For the sake of facilitating understanding, we will report only the first five most probable responses for each set of sentences, but all responses, their probability index and the class of verbs they belong to may be found in Supplemental Material C.

The verb with the highest probability of appearance after subject-initial phrases was 'decir' (*to say*; $p = .16$), followed by 'dar' (*to give*; $p = .10$), 'pegar' (*to hit*; $p = .06$), 'pedir' (*to ask for*; $p = .06$), and 'contar' (*to tell*, $p = .05$). As for object initial sentences, verbs with the highest production probability were 'gustar' (i.e. *to like*; $p = .52$), 'encantar' (*to love*; $p = .08$), 'doler' (*to hurt*; $p = .05$), 'dar' (*to give*; $p = .05$), and 'dar + N' (i.e. *to feel scared, laughter, etc.* $p = .05$).

As for the qualitative analysis, in nominative-initial sentences, out of 182 responses, 172 involved an activity verb. The remaining ten were object experiencer psych verbs ($N = 5$), or a state verb with a subject experiencer ($N = 5$). In dative-initial sentences, out of 182 responses, 125 involved an object experiencer verb, 24 corresponded to states or changes of state verbs (e.g. 'crecer' as in 'A María le creció el pelo', *Mary's hair grew*, or 'salir' as in 'A María le salió una ampolla en el pie', 'María's got a blister on her foot'), 7 were activity verbs, and 26 were activity verbs with a plural inflection.

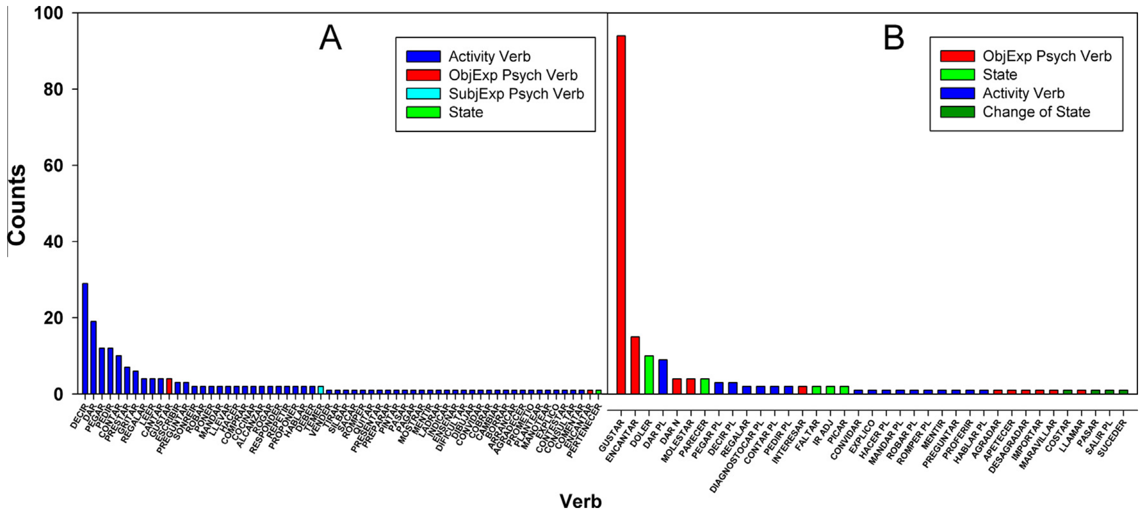

Fig. 4. Distribution of probability of responses (N = 182) given at the current completion task for SVO (A) and OVS (B) sentences.

The distribution of responses shows a very interesting dissociation between the lexical and the thematic content of the responses that participants give after a nominative or dative-initial structure. As it may be seen in Fig. 4A, subject-initial sentences elicited more lexical tokens than object-initial structures, but mostly from the same class of verb (i.e. Activity verbs). Except for the five sentences that contained the ObjExp psych verb, in all the sentences, the nominative argument was interpreted semantically as the Actor – or more actor-like argument in the case of SubjExp verbs.

The distribution of probabilities of object-initial sentences (Fig. 4B) showed that even when it is true that most responses corresponded to an ObjExp psych verb (N = 125), 94 of them were any form of the verb 'gustar' (*to like*). The rest of the responses were almost evenly divided between activity verbs, and states and change of state verbs. Interestingly, most of the activity verbs elicited in this condition contained a plural inflection, and no overt subject. This type of impersonal construction is used when the subject of the sentence is either non-specific or redundant, e.g. 'A María le robaron el auto.' ('María had her car stolen') or 'A María le diagnosticaron cancer.' ('María was diagnosed with cancer.' Moreno, 1990), thus emphasising the process that the overt constituent is going through. Consequently, most of the responses (N = 175) show that participants yielded sentences in which the first constituent was given the most prominent status according to its case (i.e. Experiencer in sentences with ObjExp verbs, and undergoers of sentences with an activity verb in impersonal sentences.). However, there is a clear preference for one of the lexical items, namely 'gustar'. In order to establish how unpredictable a new piece of information is (in this case, new information is provided by upcoming words in a sentence), we calculated the entropy of subject-initial and object-initial constructions by using the responses provided by the participants. To put it briefly, the more unpredictable a new piece of information is, the higher the entropy. Following (Shannon, 1951), for each word order we calculated entropy as minus the sum of all responses probabilities multiplied by the log base two of each probability, as seen in:

$$H(X) = -\sum_i p(x_i)\log_2 p(x_i) \quad (1)$$

in which X represents the input provided (in this case subject or object-initial structures), i represents the responses given, and p stands for the probability of each response.

In order to calculate the lexical entropy, we took into account each verb as a separate event, while thematic entropy was calculated by grouping responses by the type of thematic structure they contain.

Analysis of the structures' entropy showed that for nominative-initial sentences there is more uncertainty regarding the type of lexical item that may follow (H = 5.03) when compared with dative-initial sentences (H = 3.18). This pattern is reversed when entropy is calculated according to the class of verb that is expected. There is higher uncertainty regarding the verb type that will appear for dative-initial sentences (H = 1.35) than for nominative-initial sentences (H = .36).

6. General discussion

The EEG recording showed a distinct pattern of results for subject-initial and object-initial sentences. Recall that at the verb onset, SVO sentences elicited a P600 component when a psych verb was presented, and OVS sentences elicited an N400 effect when an activity verb was introduced. The cloze probability task showed a dissociation between both types of sentences that could provide a better insight of the interpretation of both electrophysiological components. Crucially for the ERP experiment conducted in this work, the completion task showed a dissociation in terms of lexical and thematic uncertainty: On the one side, SVO sentences present a higher entropy when the type of lexical token is analysed when compared to OVS sentences. On the other hand, SVO sentences present a lower entropy when the type of thematic structure is considered when compared to OVS sentences. Also recall that one of the main differences between SVO and OVS sentences is related to the amount of information available previous to the appearance of the verb. The use of the dative clitic previous to the verb could either co-referentially repeat the information provided by the object (as in OVS sentences) or introduce new information (as in SVO sentences). Altogether, these findings suggest that the N400 and P600 found for object and nominative-initial constructions respectively are related to the interplay between the difficulty of integration of distinct types of linguistic information and thematic hierarchization processes due to differences in the amount of information available before the verb is finally revealed.

Previous studies have shown that there is an inverse correlation between the probability of appearance of a lexical item given a context – cloze probability – and the amplitude of the N400 component: the lower its cloze probability, the higher the N400 amplitude (DeLong et al., 2005; Federmeier & Kutas, 1999; Frank et al., 2015; Kutas & Hillyard, 1984). Furthermore, there is a growing body of evidence that shows that the P600 effect may be elicited by grammatical sentences at points where syntactic and semantic integration difficulty is increased compared to control cases (Bornkessel & Schlesewsky, 2008; Chow & Phillips, 2013; Hagoort, 2009; Kaan, Harris, Gibson, & Holcomb, 2000; Kim & Osterhout, 2005; Kolk, Chwilla, van Herten, & Oor, 2003). In the current experiment, the N400 may be partly accounted for by the need of reanalyzing the prominence given to the first argument, but also, by the appearance of a lexical item different to the one expected, as shown by the cloze-probability of the verb 'gustar' in comparison to the remaining verbs elicited during the completion task. Conversely, the elicitation of the P600 effect in SVO sentences seems to be grounded on the appearance of a verb that requires prominence reversal, but which also is thematically incompatible with the participants' expectations, as it is shown by the low entropy of nominative initial constructions regarding the type of verb that is expected.

Turning to the initial question of this paper about the role of prominence information availability prior to the verb, the dissociation in the outcome of subject-initial and object-initial conditions also suggests that while in SVO sentences the prediction of the upcoming verb would rely mostly on the pre-activation of morphosyntactic cues, processing sentences with less prominence information available (OVS sentences) would depend more on lexical pre-activation to predict the verb to appear. These results support previous findings about the interaction between prominence cues and information span (Wang et al., 2012), which show that preactivation of prominence cues such as animacy may depend on the amount of arguments present prior to the verb. Similarly, our results show that Spanish comprehenders create stronger expectations about the type of verb that will appear when they have more prominence information available.

The current study also establishes the language specific differences between two Romance languages, namely, Italian and Spanish. In a study about argument hierarchization in Italian, Dröge et al. (2014) found that subject-initial sentences with psych verbs and object-initial sentences with activity verbs elicited a P600 component that reflected, among other possibilities, a conflict monitoring or a wellformedness mismatch due to the thematic mismatch. Furthermore, the authors found that in object-initial sentences, the appearance of an activity verb elicited a biphasic N400 component as well. The authors explain the N400 effect as the interplay of two different factors: the thematic hierarchy and lexical predictability, and they argue that, in contrast to the high predictability for a dative object experiencer verb following an initial dative, an initial subject does not lead the processing system to anticipate a dative active verb. Hence, the lower degree of lexical predictability leads to an N400 increase in SVO sentences with activity verbs, thus masking the thematic N400 effect in SVO sentences with Object experiencer verbs.

In our study, the distribution of responses of the completion task shows that although a psych verb was expected the most, the chance that an activity verb appears is larger than in Italian (18.13% against 5.45% in Italian). Therefore, if the P600 is considered as a reflex of conflict monitoring or a wellformedness mismatch (as in Dröge et al., 2014), it is possible that its absence in OVS sentences with activity verbs shows that the integration of this verb type to the preceding dative sentence frame is not as difficult as it is in Italian.

Finally, the results partly replicate the outcome from a behavioural self-paced reading study ran in Spanish (Gattei et al., 2015), which showed that participants have more difficulties to integrate verbal information when they read SVO sentences with psych verbs and OVS sentences with activity verbs. The current study adds information about the nature of this difficulty of integration (thematic on the first case and lexical on the second case) and provides further evidence for the construction of a cross-linguistic model of language comprehension.

7. Conclusion

The present study aimed to provide evidence about the role of prominence information for arguments incremental interpretation in Spanish, a language that has been briefly studied in this regard. We investigated the time course of neural correlates associated to the comprehension of sentences that require a reversal of argument prominence hierarchization. We also studied how language-specific characteristics may affect sentence processing, including the incremental build-up of expectations. In accordance with previous studies, the outcome of the offline task showed that in Spanish, comprehension is disrupted when prominence information of arguments does not follow a more-to-less prominent order. Results of the ERP data and the completion task suggest, however, that this general preference interacts with language-specific features, thus leading to qualitatively different components that depend on the amount of prominence information available before the verb is encountered. When two arguments become available prior to the verb, a reversal of arguments prominence hierarchization elicits a P600, compatible with previous results from other languages like German and Italian. However, when readers only count on prominence information from one argument prior to the appearance of the verb, expectations are built-up in terms of lexical probabilities, thus engendering an N400 when these expectations are not fulfilled.

Finally, the fact that the interaction between word order and verb class is manifested in qualitatively dissociable ERP effects (N400, P600 and early positivity) indicates that verb class information influences different levels of the language processing architecture, thus affecting the interface between syntax, semantics and discourse (information structure).

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.bandl.2015.08.001.

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