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Eppur non si muove: Experimental evidence for the Unaccusative Hypothesis and distinct ϕ -feature processing in Basque

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The Unaccusative Hypothesis (UH) has been extensively studied in linguistics, but, to date, it has not been tested by means of ERPs. The present study aimed to experimentally test the UH hypothesis in Basque and determine what the electrophysiological correlates are of the processing of unergative versus unaccusative predicates; it also aimed to investigate distinctness in phi-feature processing. We generated eight conditions to compare unergative and unaccusative predicate sentence processing involving phi-feature violations in grammatical and ungrammatical sentences. Participants responded faster to sentences containing unaccusative predicates compared to unergative predicates. All conditions elicited a N400-P600 interaction. Overall, the negativity elicited by person violations was larger than the negativity elicited by number violations in both types of predicates. Intransitives differed regarding the size of the positivity elicited by phi-feature violations: unaccusatives elicited a larger positivity for number than for person feature violations, but unergatives elicited a larger positivity for person than for number.

Keywords: ERPs; unaccusative hypothesis; subject agreement; person and number ϕ features; Basque

1 Introduction

Perlmutter (1978) put forth the Unaccusative Hypothesis (UH), claiming there are two different types of intransitive predicates: unaccusatives, with a theme theta role, and unergatives, with an agent theta role (Perlmutter 1978). According to the UH, arguments of unaccusative verbs start as objects (R2) and advance into subjects (R1) in the derivation, whereas arguments of unergative verbs start as subjects (R1). Importantly, the UH makes two claims: (i) there are two different types of argument structure involved in intransitive predicates, one has an agent as the sole argument of the verb and the other one has a theme as the sole argument of the verb (unaccusatives) and (ii) the syntactic derivation of unaccusatives involves one more step than that of unergatives, namely the promotion of the theme argument from object to subject. Burzio (1986) rephrased this second claim in the UH in the framework of Government and Binding (Chomsky 1981) in terms of syntactic movement: the theme argument of an unaccusative verb is generated as its complement and then moves to subject position, whereas the agent argument of an unergative verb is generated as an external argument.

Bever & Sanz (1997) were the first to experimentally test the UH; they conducted a reaction time study in Spanish to explore whether the trace left by the argument of unaccusative verbs in the complement of V position, argued to be an anaphor (Chomsky 1981), would prime semantically related nouns as overt anaphors do. Their results showed that

participants who scanned the linguistic sequence to find a probe word recognized it faster in preverbal position in unaccusatives than in unergative constructions, which the authors interpreted as evidence for the UH. Since this pioneering study, many other studies have tested this hypothesis experimentally; in the last decades the UH has been tested in sentence production studies on agrammatic aphasia (Thompson 2003; M. Lee & Thompson 2004; McAllister et al. 2009; J. Lee & Thompson 2011) and in healthy adults, both in sentence production (Kim 2006; J. Lee & Thompson 2011; Momma, Slevc & Phillips 2018) and in sentence comprehension. Friedmann, Taranto, Shapiro & Swinney (2008) conducted a cross-modal lexical priming experiment in English and found that subjects of unaccusatives reactivate after the verb, whereas subjects of unergatives do not. Zeyrek & Acarturk (2014) ran an eye-tracking study and the gaze regression analysis grouped intransitive verbs in two clusters with regard to the number of regressions, revealing an unergative/unaccusative split in intransitive verbs in Turkish; Koring, Mak & Reuland (2012), ran an eye-tracking study using the visual world paradigm and found that subjects were reactivated in different time intervals in Dutch unaccusative and unergative verbs; finally, Meltzer-Asscher et al. (2015) and Thompson et al. (2007) in English, and Shetreet, Friedmann & Hadar (2009) in Hebrew, using fMRI, revealed distinct activations for unaccusatives and unergatives.

These studies found differences in the representation and processing of unergative vs. unaccusative verbs, thus converging with a large body of literature in linguistics regarding this issue (Levin & Hovav 1995). However, as far as we know, there are no studies to date exploring the electrophysiological correlates of unaccusative vs. unergative sentence processing. Here we present and discuss a pioneering study testing the UH by means of Event Related Potentials (ERPs). ERPs record time-locked electroencephalographic (EEG) activity in response to sensory, cognitive or motor stimuli, which reflect the activity of postsynaptic potentials generated by a large number of similarly oriented cortical pyramidal neurons firing in synchrony (Luck 2014). Although quite poor with regard to spatial resolution, this electrophysiological non-invasive method provides an excellent temporal resolution, as it records neuronal activity millisecond by millisecond. Thus, ERPs allow us to continuously measure brain activity and to analyze how different stimuli are represented and processed. This study seeks to uncover the electrophysiological correlates of the representation and processing of unaccusative and unergative predicates. Our study is carried in Basque, an ergative language, and it deploys the subject verb agreement violation paradigm, frequently used in ERP studies.

Subject agreement has been widely studied cross-linguistically in the ERP literature, also in Basque. As a result, subject agreement violations afford a very suitable ground to test the UH by means of this technique. In what follows, we provide a brief review of the literature related to ERP studies on subject agreement processing as a background for our study.

1.1 Electrophysiological correlates of subject-verb agreement

Subject-Verb Agreement is among the most studied phenomena in the ERP literature on language processing (for a review see Molinaro, Barber, & Carreiras 2011). Subject-agreement violations elicit a centro-parietal positivity (P600), preceded in most cases by a Left-Anterior Negativity (LAN). The P600 component, also known as the Syntactic Positive Shift (SPS), is usually related to syntactic ungrammaticality or complexity. The LAN component is a brain response associated to the early detection of morpho-syntactic violations (Molinaro et al. 2011; Tanner 2015 among others).

The electrophysiology of subject-verb agreement violation in Basque has been studied in transitive sentences (Chow, Nevins & Carreiras 2018; Díaz, Sebastián-Gallés et al. 2011; Zawiszewski & Friederici 2009; Zawiszewski, Santesteban & Laka 2016) and, therefore, this paradigm offers an adequate comparison for unergative and unaccusative predicates.

Zawiszewski & Friederici (2009) investigated agreement in Basque by looking at subject and object-verb agreement violations. They reported a N400-P600 pattern for the first time regarding subject agreement violations, and ever since this pattern has been consistently found in subsequent studies in Basque (Zawiszewski et al. 2011; 2016; Chow et al. 2018). The N400 was originally associated with the processing of semantic incongruities and violations (Kutas & Hillyard 1980; Kutas & Hillyard 1983), and has since also been interpreted as indexing problems with thematic role assignment (Frisch & Schlesewsky 2001).

Díaz et al. (2011) explored whether ERP components elicited by case and verb agreement are cross linguistically equivalent. They found a P600 but no negativities in subject-verb agreement violations and offered two possible explanations for the lack of N400 in subject-verb violations in contrast to Zawiszewski & Friederici (2009): (a) the feature violated in this study was number (3rd person plural vs. 3rd person singular), whereas in the study by Zawiszewski & Friederici (2009) this factor was not controlled for by the authors (the materials included the mixture of person/number and person + number manipulations); (b) the sentences in Díaz et al. (2011) were presented auditorily, whereas they were presented visually in Zawiszewski & Friederici (2009).

Zawiszewski et al. (2016) investigated whether phi-features are processed distinctly, and for that purpose they carried out a study in Basque where person, number or person + number features were violated. A N400-P600 pattern was elicited for all conditions, replicating the findings in Zawiszewski & Friederici (2009). A larger P600 emerged for person and number + person violations than for number violations, revealing different costs related to the processing of person versus number phi-features.

Chow et al. (2018) studied the effects of subject-case marking on agreement processing by comparing transitive and unaccusative sentences in Basque. A P600 emerged for violations in both transitives and unaccusatives, but a negativity emerged only for violations in sentences headed by unaccusative verbs. The authors interpret this finding as supporting the idea that the auxiliary verb in Basque cannot support more than one instance of “true” agreement and that whenever there is a 3rd person ergative agreement, this agreement is achieved via pronominal clitic doubling (Arregi & Nevins 2012). According to the authors true agreement in Basque only occurs with 3rd person absolutive subjects (unaccusatives). As a result, they interpret that the early posterior negativity elicited in their study constitutes evidence for this claim.

1.2 Case and agreement morphology in Basque

The language tested in this study is Basque, an agglutinating SOV language isolate, and the only active-ergative language found in western Europe (De Rijk 2007). Basque has rich multipersonal agreement, as the verb obligatorily agrees with the subject, direct object and the indirect object (1):

- (1) Zu-k ni-ri liburu-ak eman di-zki-da-zu.
 you-ERG me-DAT book-DET.PL given have-PL.ABS-1SG.ABL-2SG.ERG
 ‘You have given me (the) books.’

As originally discussed by Levin (1983), Basque agentive subjects carry ergative case, both in transitives (2a) and in unergatives (2b), but theme arguments always carry absolutive case both as subjects of unaccusatives (2c) and as objects of transitive (2a) sentences.

- (2) a. Zu-k lagun-a ikusi du-zu.
 you-ERG friend-DET.SG seen have-2SG.ERG
 ‘You have seen the friends.’
- b. Zu-k mendian eskiatu du-zu.
 you-ERG mountain.the.in skied have-2SG.ERG
 ‘You have skied in the mountain.’
- c. Zu etxera joan z-ara.
 you.ABS home.to gone 2SG.ABS-be
 ‘You have gone home.’

Hence, as already discussed by Levin (1983) unaccusatives and unergatives are morphologically distinct in Basque: unaccusatives have absolutive (zero) marked subjects and select auxiliary *be*, while unergatives have ergative marked subjects and select auxiliary *have*. Accounts of case assignment in Basque differ: some authors argue that case in Basque is assigned structurally, and therefore, the sole argument of an unaccusative verb undergoes movement to Spec IP to receive case (Ortiz De Urbina 1989; Preminger 2012; Rezac, Albizu & Etxepare 2014), others argue that case is inherent, that is, signaling thematic role and independent of tense. The second hypothesis argues that there is no need to postulate syntactic movement to receive case for unaccusative sentences in this language (Laka 2006a, b; Laka 2017; Levin 1983). Basque is an active-ergative language and it differs from other ergative languages such as Warlpiri, Burushaski or West Greenlandic (see Baker & Bobaljik 2017; Laka 2006b; 2017; Levin 1983), where ergativity is a signal of transitivity. It has also been argued there to be dialectal differences regarding ergativity in Basque. Western varieties seem to have an active-inactive pattern similarly to Georgian and Native American languages, whereas Eastern varieties resemble *bona-fide* ergative languages (Aldai 2009).

2 The present study

The present study aimed to determine what the behavioural and electrophysiological correlates are of the processing of unergative versus unaccusative predicates in Basque. We do this by exploring person versus number subject agreement. A $2 \times 2 \times 2$ design was used for the experiment. We manipulated the TYPE of the predicate (2 levels: unaccusative vs. unergative), the FEATURE (2 levels: person and number) and the GRAMMATICALITY factors (2 levels: grammatical and ungrammatical).

2.1 Hypotheses and predictions

The main goal of this study is to test whether different processing patterns of electrophysiological correlates obtain for subject agreement violations in unaccusatives and unergatives, testing person and number features separately. We are thus testing the following hypotheses in the current study:

(H1) *The Unaccusative Hypothesis* (UH). This hypothesis makes two claims. First, it claims that there are two types of intransitive predicates, unaccusatives (assigning theme theta role) and unergatives (assigning agent theta role) (Perlmutter 1978). This first part of the UH predicts that the differences that obtain in the processing of these two types of predicates should have unergatives look more similar to transitive predicates because both contain agentive subjects and less similar to unaccusatives because they involve theme subjects.

The UH further claims that these two predicates undergo different syntactic derivations: the theme arguments of unaccusatives are first generated as objects and become subjects during the derivation, whereas the agentive argument of unergative verbs is already born as a subject. In both Perlmutter's (1978) and Burzio's (1986) rendition, the second claim of this hypothesis entails that unaccusatives involve more complex derivations than unergatives, due to the fact that arguments of unaccusative verbs have to either be promoted to subject (Perlmutter 1978) or undergo movement and leave a trace (Burzio 1986). Recall that, regarding the effects of this second part of the UH, there are two contrasting hypotheses regarding the Basque language: some authors claim that unaccusatives in this language also involve this extra derivational step (Ortiz De Urbina 1989) whereas others claim that they do not (Laka 2006a, b; Levin 1983). Longer, more complex syntactic derivations correlate with greater processing costs (Erdocia et al. 2009; Matzke et al. 2002), which is signalled behaviourally by longer reading times/or reaction times and also by ERP signatures, either by larger negativities or positivities for unaccusatives as compared to unergatives.

(H2) *The Feature Distinctness Hypothesis* (FDH)¹ that we put forth here claims person and number are processed and represented differently, yielding distinct processing signatures. Molinaro, Rizzi & Carreiras (2011) propose the Person-Number Dissociation Hypothesis (PNDH), arguing that person and number features are intrinsically different, as person conveys extra-syntactic information concerning the participants in the speech act. We hypothesize that person is more salient than number in processing. The FDH predicts that different electrophysiological responses will emerge for person and number violations. Moreover, based on (Zawiszewski et al. 2016; Chow et al. 2018) we expect to find a N400 component for violations in both unergative and unaccusative predicate violations, and based on (Zawiszewski et al. 2016) we expect to find a larger P600 for person than for number violations.

2.2 Experiment

2.2.1 Participants

Twenty-five neurologically healthy native speakers of Basque took part in the experiment: 7 males and 17 females, all of them graduate and undergraduate students at the University of the Basque Country with a mean age of 19,8 years (SD 2.6).² They were all right-handed (Edinburgh Handedness inventory: Oldfield 1971), and they were all paid (20€) for their participation. Data from one participant was excluded due to excessive eye movements and other artefacts.

2.2.2 Materials

The experiment was designed in standard Basque. Four lists each consisting of 416 sentences (256 experimental and 160 fillers) were created. We then created 8 conditions (see Table 1): Condition 1, unaccusative person grammatical; Condition 2, unaccusative person ungrammatical; Condition 3, unaccusative number grammatical; Condition 4, unaccusative number ungrammatical; Condition 5, unergative person grammatical; Condition 6, unergative person ungrammatical; Condition 7, unergative number grammatical and Condition 8, unergative number ungrammatical. The critical words were the auxiliary verbs, which were always preceded by the main verbs, all controlled with respect to length and frequency.

¹ Do not confuse H2 with Carminati's (2005) Feature Strength Hypothesis, whereby a correlation is assumed between the cognitive significance of a feature and its disambiguating power.

² Speakers of eastern varieties were not considered for this study due the dialectal differences mentioned in 1.2.

Table 1: Experimental conditions with examples of experimental materials.

Conditions			Sentence examples
Predicate Type	Feature	Grammaticality	
Unaccusative	Person	grammatical	Zu gaur goizean bueltatu zara Bilbotik. you-ABS today morning.in returned 2SG.ABS-be Bilbao-from “You have come back from Bilbao this morning.”
		ungrammatical	*Zu gaur goizean bueltatu naiz Bilbotik. you-ABS today morning.in returned 1SG.ABS-be Bilbao-from
	Number	grammatical	Hura gaur goizean bueltatu da Bilbotik. 3.SG-ABS today morning.in returned 3SG.ABS-be Bilbao-from
		ungrammatical	*Hura gaur goizean bueltatu dira Bilbotik. 3.SG-ABS today morning.in returned 3PL.ABS-be Bilbao-from
Unergative	Person	grammatical	Zuk goizean biziki sufritu duzu you-ERG morning a.lot suffered have-2SG.ERG aurkezpenean. presentation-the-at “You have suffered a lot this morning at the presentation.”
		ungrammatical	*Zuk goizean biziki sufritu dut you-ERG morning a.lot suffered have-1SG.ERG aurkezpenean. presentation-the-at
	Number	grammatical	Hark goizean biziki sufritu du 3.SG-ERG morning a.lot suffered have-3SG.ERG aurkezpenean. presentation-the-at
		ungrammatical	*Hark goizean biziki sufritu dute 3.SG-ERG morning a.lot suffered have-3PL.ERG aurkezpenean. presentation-the-at

In Basque there are two types of unergatives: the ones that consist of a bare noun and a light predicate *egin* (‘do’), and the others consisting of one word. The former cannot take a further DP direct object and many linguists consider that they are transitive in nature (Bobaljik 1993; Hale & Keyser 1993; Laka 1993; 2006b). As a result, in the present study one-word unergatives were used so that the number of words would not vary in comparison to unaccusatives, given the extreme sensitivity of ERPs to the phonological size and number of the items to compare. Examples of each are provided in (3) (for the full list of experimental materials, see Supplementary Materials in the appendix to this paper):

- (3) a. Klara-k **dantza-tzen** du.
Klara-ERG dance-IMPF have.3SG.ERG
- b. Klara-k **dantza egi-ten** du.
Klara- ERG dance do-IMPF have.3SG.ERG
‘Clare dances.’

Previous ERP studies involving phi-features used different types of materials. Zawiszewski et al. (2016) used 2nd instead of 1st persons to violate person and 2nd person singular instead of plural to violate number. Mancini et al. (2011) used 3rd instead of 2nd persons to violate person, and 3rd person plural instead of singular to violate number. It is generally agreed in linguistics that third person lacks person feature (Benveniste 1966), and only 1st and 2nd person have person feature, as they involve participants in the speech act. If this is correct, then the person violation in Mancini et al. (2011) might not involve a person violation at all. Given this caveat, also discussed in Zawiszewski et al. (2016), we decided

to use 2nd instead of 1st for person violations. We followed Mancini et al. (2011) in using 3rd singular vs. plural for number violations.

2.2.3 Procedure

Personal computers (Windows 7 operating system) and Presentation software (version 16.3) were used to present the stimuli on screen. Before the actual experiment started, participants were instructed about the EEG procedure and seated comfortably in a quiet room in front of a 24 in. monitor. The experiment was conducted in a silent room in the Experimental Linguistics Laboratory at the University of the Basque Country (UPV/EHU) in Vitoria-Gasteiz. Sentences were displayed in the middle of the screen word by word for 350 ms (ISI = 250). A fixation cross (+) indicated the beginning of each sentence trial. After each trial the words *zuzen?* ‘correct?’ or *oker?* ‘incorrect?’ appeared in the screen, and participants were asked to judge the acceptability of the previously displayed sentence as either correct (left Ctrl) or incorrect (right Intro). Half of participants used the left hand for correct responses and the other half the right hand.

All 416 sentences were distributed randomly in four blocks that lasted approximately 10 min each. Participants had a short break between each block which lasted as long as they needed. Before the actual experiment, participants ran a short training session of three trials. They were asked to avoid blinking or moving when the sentences were being displayed and to make the acceptability judgment as fast and accurately as possible. The whole experiment, including electrode-cap application and removal, lasted about 1 h 15 m.

2.2.4 EEG recording

The EEG was recorded from 32 active electrodes secured in an elastic cap (Acticap System, Brain Products). Electrodes were placed on standard positions according to the extended International 10–20 system in the following sites: Fp1/Fp2, Fz, F3/F4, F7/F8, FC5/FC6, FC1/FC2, T7/T8, C3/C4, Cz, CP5/CP6, CP1/CP2, P7/P8, P3/P4, Pz, O1/O2, Oz, LM, VEOG and HEOG. All recordings were referenced to right mastoid position and re-referenced off-line to the linked mastoids. Vertical and horizontal eye movements and blinks were monitored by means of two electrodes positioned beneath and to the right of the right eye. Electrode impedance was kept below 5 kOhm at all scalp and below 10 kOhm for the eye electrodes. The electrical signals were digitized online at a rate of 500 Hz by a Brain Vision amplifier system and filtered offline within a band pass of 0.1–35 Hz. After the EEG data were recorded, the ocular correction procedure (Gratton, Coles & Donchin 1983) as well as the artifact rejection procedure were applied (offline). Trials with other artifacts were removed indicated by any voltage exceeding 150 μ V and voltage steps between two sampling points exceeding 35 μ V.

2.2.5 Data analysis

For the data analysis the following types of subject agreement violations were compared: unaccusative person violations (*zara* ‘be.2SG’ vs. **naiz* ‘be.1SG’; conditions 1 vs. 2 in Table 1, respectively); unaccusative number violations (*da* ‘be.3SG’ vs. **dira* ‘be.3PL’; conditions 3 vs. 4 in Table 1, respectively); unergative person violations (*duzu* ‘have.2SG’ vs. **dut* ‘have.1SG’; conditions 5 vs. 6 in Table 1, respectively); unergative number violations (*du* ‘have.3SG’ vs. **dute* ‘have.3PL’; conditions 7 vs. 8 in Table 1, respectively).

For the ERP measures, segments were created from 200 ms before and 1000 ms after the onset of the critical words (the auxiliary) in the sentences. The trials associated with each sentence type were averaged for each participant. The EEG 200 ms prior to the onset was also used as a baseline for all sentence type comparisons.

300–400 ms and 400–700 ms temporal windows were considered during statistical analysis in all conditions based on the literature and visual inspection of the data. After the stimuli were recorded and averaged, analyses of variance (ANOVA) were carried out in nine regions of interest that were computed out of 27 electrodes: lateral electrodes: left frontal (F7, F3, FC5), left central (T7, FP5, C3), left parietal (P7, P3, O1), right frontal (F4, F8, FC6), right central (C4, FP6, T8), and right parietal (P8, P4, O2); midline electrodes: frontal (Fp1, Fz, Fp2), central (FC1, Cz, FC2), and parietal (CP1, Pz, CP2). Repeated-measures ANOVAs were performed in all experimental manipulations and trials (correctly and incorrectly judged trials) for each window of time using five within-subjects factors: grammaticality (2 levels: grammatical, ungrammatical), type (2 levels: unaccusative, unergative), feature (2 levels: person, number), hemisphere (2 levels: left, right), and region (3 levels: frontal, central and parietal). Midline (frontal, central, and parietal) electrodes were analyzed independently. Whenever the sphericity of variance was violated (Greenhouse & Geisser 1959) correction was applied to all the data with greater than one degree of freedom in the numerator. Finally, further statistical comparisons were conducted (split by the grammaticality condition) whenever an interaction turned out to be statistically significant. Effects for the type, feature, hemisphere or region factors are only reported when they interact with the experimental manipulation of grammaticality.

For the behavioral results, error rates and response latencies of all the trials were submitted to repeated measures ANOVAs with grammaticality (two levels: grammatical, ungrammatical), type (two levels: unaccusative, unergative) and feature (two levels: person, number) conditions as within-subjects factors. Subsequent comparisons (by subject and by item) were carried out whenever a grammatical interaction was significant.

3 Results

3.1 Behavioural results

Participants were very accurate in the acceptability task, as they were native and competent speakers (mean accuracy of 92.74%, SDE = 1.35; see Table 2).

Regarding acceptability judgment errors, the analysis showed a significant GRAMMATICALITY effect in the analysis by item ($F1(1,23) = 3.12, p = .091$; $F2(1,254) = 12.25, p = .001$) revealing higher accuracy for the ungrammatical sentences as compared to the grammatical ones (94.08% vs. 91.38%). A FEATURE effect turned out to be statistically significant as well ($F1(1,23) = 18.17, p < .001$; $F2(1,254) = 16.96, p < .001$). This effect showed that participants judged more accurately materials containing person feature manipulations than those with number feature manipulations (94.3%

Table 2: Percentage of correct responses and mean reaction times in milliseconds, standard deviation errors (SDE) between parentheses.

	Accuracy (%)	Reaction times (ms)
unaccusative person gram	93.5 (1.1)	686.3 (44.5)
unaccusative person ungram	95.6 (0.8)	529.2 (36.9)
unaccusative number gram	89.5 (1.6)	683.9 (42.2)
unaccusative number ungram	93.5 (1.7)	527.9 (28.3)
unergative person gram	92.1 (1.5)	723.3 (44.8)
unergative person ungram	96.1 (1.1)	496 (23.9)
unergative number gram	90.5 (1.4)	757.5 (52.4)
unergative number ungram	91.1 (1.6)	578.9 (35.4)

vs. 91.15%). Finally, a TYPE*GRAMMATICALITY*FEATURE interaction was marginally significant in the analysis by subject ($F(1,23) = 3.35, p = .08; F(1,254) = 2.81, p = .095$). The subsequent analysis by type factor revealed no significant differences between the experimental conditions. The analyses by grammaticality factor showed that the difference in accuracy between grammatical and ungrammatical sentences was marginally significant for unaccusatives in the person condition and non-significant in the number condition. A similar pattern emerged for unergatives: the difference between grammatical and ungrammatical sentences was significant in the person condition and non-significant in the number condition (unaccusative person ($F(1,23) = 3.93, p = .059$); unaccusative number ($F(1,23) = 2.33, p = 0.14$); unergative person ($F(1,23) = 4.54, p = .044$); unergative number ($F(1,23) = 0.13, p = .727$)). The analyses by feature factor showed significant differences between person and number features when comparing unaccusative grammatical conditions ($F(1,23) = 8.15, p = .009$), but not when comparing the unaccusative ungrammatical conditions ($F(1,23) = 1.98, p = .173$), that is, the participants were more accurate when performing the task in the person feature condition than in the number feature condition. Regarding the unergatives, the analyses revealed no differences between person and number features when comparing grammatical conditions ($F(1,23) = 1.68, p = .207$) and a higher accuracy in person than in number when comparing ungrammatical conditions ($F(1,23) = 11.74, p = .002$).

Regarding response latencies, a significant main effects of GRAMMATICALITY ($F(1,23) = 53.58, p < .001; F(1,254) = 251.14, p < .001$) showed larger response times for the grammatical conditions as compared to the ungrammatical ones (712.75 ms vs. 532.38 ms). A main effect of FEATURE ($F(1,23) = 4.6, p = .044; F(1,254) = 2.95, p = .087$) revealed shorter response times when judging the grammaticality of the sentences containing person feature manipulations in comparison to the sentences containing number feature manipulations (608.07 ms vs. 637.06 ms). A main effect of TYPE present in the by-subject analysis ($F(1,23) = 5.65, p = .026; F(1,254) = 3.14, p = .078$) showed shorter response latencies in unaccusative sentences as compared to unergatives (606.21 ms vs. 638.92 ms). A TYPE*GRAMMATICALITY interaction was marginally significant in the by subject analysis ($F(1,23) = 3.14, p = .09; F(1,254) = 3.06, p = .082$). Further comparisons (by type factor) revealed that participants were slower at processing grammatical unergative sentences (740.4 ms) in contrast to grammatical unaccusatives (685.1ms) ($F(1,23) = 5.91, p = .023$) while no differences between the ungrammatical unergative (537.5 ms) and ungrammatical unaccusative conditions (527.3 ms) were found ($F(1,23) = 0.56, p = .463$). The comparisons by grammaticality factor showed that participants were slower when responding to grammatical sentences in the unaccusative condition (685.1 ms) as compared to the ungrammatical sentences (527.3 ms) ($F(1,23) = 39.1, p < .001$). A similar pattern emerged when comparing the grammatical unergative condition to the ungrammatical one: participants were slower when judging the grammatical sentences (740.4 ms) in comparison to the ungrammatical ones (537.5 ms) ($F(1,23) = 45.69, p < .001$).

3.2 ERP results

After the baseline correction, epochs with artifacts were rejected, which resulted in the exclusion of approximately 10.8% (SD = 0.6) of the trials. Based on the previous literature and visual inspection of the data we selected an early time window (300–400 ms) and a late time window (400–700 ms) in order to capture best the effects obtained (see Figure 1 for the grand average patterns and Figure 2 for the mean voltage difference maps and Table 3 below for the summary of the statistical results).

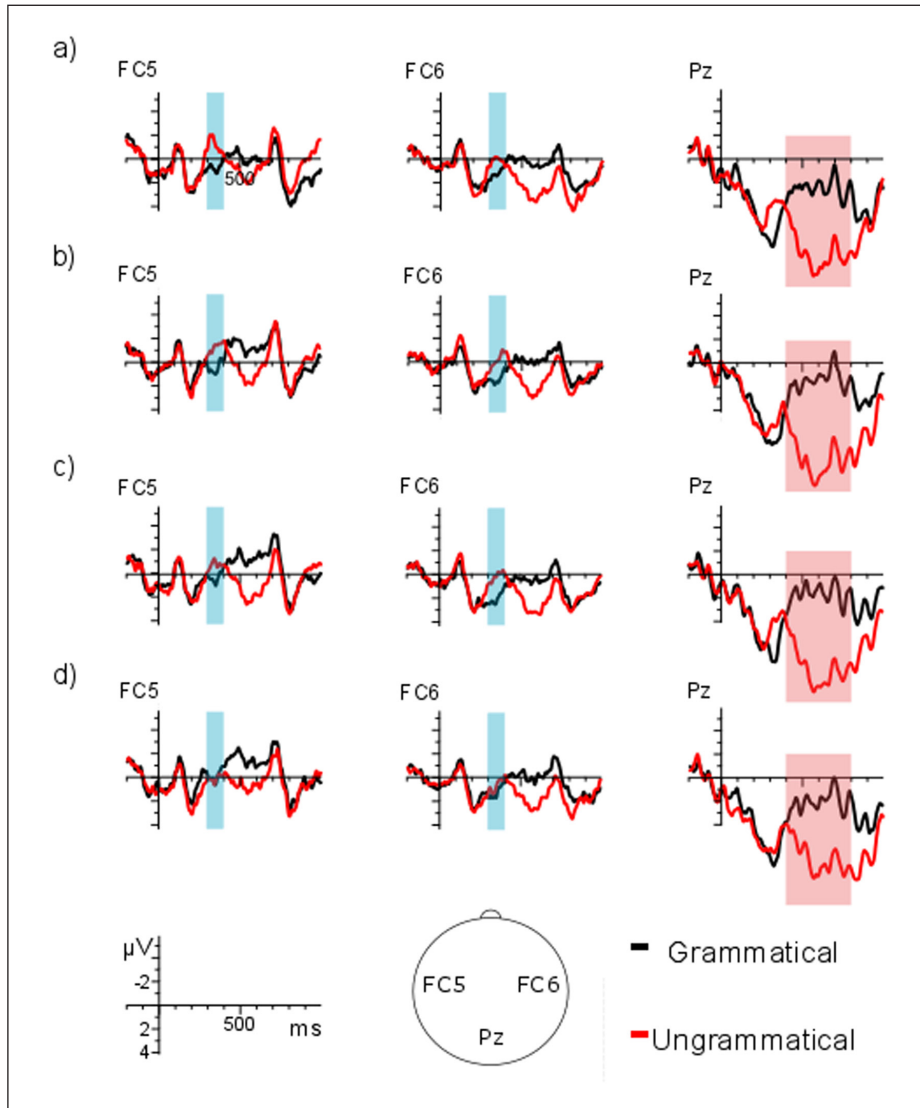


Figure 1: (a) person feature unaccusative predicate condition; (b) number feature unaccusative predicate condition; (c) person feature unergative predicate condition; (d) number feature unergative predicate condition.

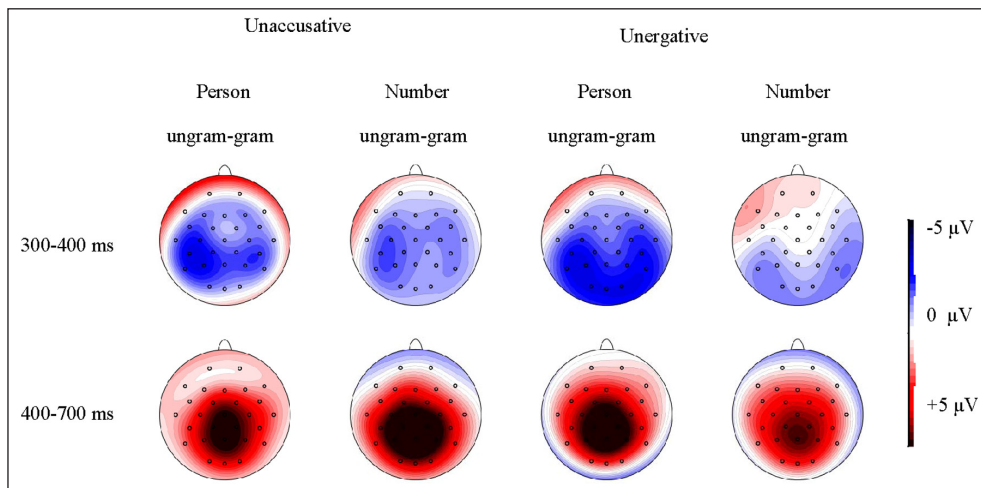


Figure 2: Mean voltage difference maps (grammatical minus ungrammatical).

Table 3: Summary of the ERP results. Main effects and interactions with grammaticality are shown. GRAM (grammaticality), TYPE (type), FEAT (feature), HEM (hemisphere) and REG (region). * $p < .05$, ** $p < .01$, *** $p < .001$.

	df	300–400 ms		400–700 ms	
		Lateral	Midline	Lateral	Midline
		F	F	F	F
GRAM	1,23	***32.9	**9.63	***47.26	***62.47
TYPE	1,23	.64	.473	1.71	3.03
FEAT	1,23	*4.31	.278	1.74	2.89
TYPE*GRAM	1,23	.64	1.66	.57	.5
FEAT*GRAM	1,23	*10.56	*5.22	.24	.7
TYPE*FEAT*GRAM	1,23	1.76	1.68	2.6	*5.3
GRAM*HEM	1,23	.2	–	.0	–
TYPE*GRAM*HEM	1,23	3.13	–	1.57	–
FEAT*GRAM*HEM	1,23	0.83	–	.88	–
TYPE*FEAT*GRAM*HEM	1,23	.19	–	1.59	–
GRAM*REGION	2,46	**8.14	*4.85	***18.77	***35.64
TYPE*GRAM*REG	2,46	2.73	.3	*6.34	1
FEAT*GRAM*REG	2,46	.84	2.08	1.08	.55
TYPE*FEAT*GRAM*REG	2,46	.13	.88	.87	2.59
GRAM*HEM*REG	2,46	*5.05	–	.5	–
TYPE*GRAM*HEM*REG	2,46	.17	–	.29	–
FEAT*GRAM*HEM*REG	2,46	.22	–	.66	–
TYPE*FEAT*GRAM*HEM*REG	2,46	.17	–	.18	–

3.2.1 300–400 ms time window

The analysis of the lateral electrodes revealed a main GRAMMATICALITY effect ($F(1,23) = 32.9$, $p < .001$) indicating larger negativity for the ungrammatical conditions as compared to the grammatical ones ($0.91 \mu\text{V}$ vs. $2.26 \mu\text{V}$). It also revealed a significant FEATURE effect ($F(1,23) = 4.31$, $p = .049$) indicating that person is more negative than number ($1.35 \mu\text{V}$ vs. $1.82 \mu\text{V}$). In addition, a significant FEATURE*GRAMMATICALITY interaction was found ($F(1,23) = 10.56$, $p = .004$). Further analysis (by grammaticality) showed a significantly larger negativity for the ungrammatical person condition ($0.46 \mu\text{V}$) in comparison to the grammatical one ($2.24 \mu\text{V}$) ($F(1,23) = 45.95$, $p < .001$) and a larger negativity for the ungrammatical number condition ($1.37 \mu\text{V}$) in comparison to the grammatical number condition ($2.28 \mu\text{V}$) ($F(1,23) = 10.65$, $p = .003$). The comparison by feature revealed no differences between the grammatical person ($2.22 \mu\text{V}$) and number feature ($2.23 \mu\text{V}$) conditions ($F(1,23) = 0.02$, $p = .9$), but larger negativity for the ungrammatical person manipulations ($0.46 \mu\text{V}$) in comparison to the number manipulations ($1.37 \mu\text{V}$) ($F(1,23) = 13.73$, $p = .001$).

Regarding the midline electrodes, a main effect of GRAMMATICALITY showed that overall ungrammatical conditions ($2.65 \mu\text{V}$) displayed larger negativity than grammatical conditions ($3.64 \mu\text{V}$) ($F(1,23) = 9.63$, $p = .005$). A FEATURE*GRAMMATICALITY interaction ($F(1,23) = 5.22$, $p = .032$) (by grammaticality factor) revealed larger negativity for the ungrammatical person condition ($2.26 \mu\text{V}$) than for the grammatical person condition ($3.62 \mu\text{V}$) while no significant differences were found between the number conditions ($3.04 \mu\text{V}$ vs. $3.66 \mu\text{V}$) (person: $F(1,23) = 15.63$, $p = .001$; number: $F(1,23) =$

2.66, $p = .117$). In the analysis by feature factor, no differences between the person and the number conditions were observed in the grammatical conditions ($F(1,23) = 0.13$, $p = .719$) while a significant difference emerged between the ungrammatical person and number conditions, showing larger negativity for the ungrammatical person (2.26 μV) than for the ungrammatical number (3.04 μV) ($F(1,23) = 10.93$, $p = .003$).

3.2.2 400–700 ms time window

The analysis of the lateral electrodes showed a main effect of GRAMMATICALITY ($F(1,23) = 47.26$, $p < .001$, that is, overall the ungrammatical sentences elicited larger positivity than the grammatical ones (2.59 μV vs. 0.18 μV). Also, a TYPE*GRAMMATICALITY*REGION interaction was statistically significant ($F(2,46) = 6.34$, $p = .012$). The analysis of this interaction by grammaticality factor revealed a larger positivity for the ungrammatical unaccusative condition than for the grammatical unaccusative condition and for the ungrammatical unergative condition than for the grammatical unergative condition over the frontal, central and parietal regions (unaccusative frontal: $F(1,23) = 11.65$, $p = .002$; unaccusative central: $F(1,23) = 53.97$, $p < .001$; unaccusative parietal: $F(1,23) = 52.64$, $p < .001$; unergative frontal: $F(1,23) = 19.09$, $p < .001$; unergative central: $F(1,23) = 38.37$, $p < .001$; unergative parietal: $F(1,23) = 22.11$, $p < .001$). The analysis of this interaction by type factor showed unaccusative grammatical conditions were marginally more positive than unergatives only over the frontal electrodes (frontal: $F(1,23) = 3.37$, $p = .079$). The positivity found over the centro-parietal regions was marginally larger in the ungrammatical unaccusative condition as compared to the ungrammatical unergative condition (central: $F(1,23) = 3.12$, $p = .091$; parietal: $F(1,23) = 3.84$, $p = .062$).

Regarding the midline electrodes, main effects of GRAMMATICALITY ($F(1,23) = 62.47$, $p < .001$) was found, indicating larger positivity for the ungrammatical sentences (4.98 μV) as compared to the grammatical ones (1.11 μV). In addition, a significant TYPE*FEATURE*GRAMMATICALITY interaction was found ($F(1,23) = 5.3$, $p = .031$). The analysis by grammaticality factor showed that the positivity elicited by the ungrammatical sentences was significantly larger than that yielded by the grammatical sentences in both unaccusative and unergative predicates and for both person and number features (unaccusative person: $F(1,23) = 34.45$, $p < .001$; unaccusative number: $F(1,23) = 49.51$, $p < .001$; unergative person: $F(1,23) = 62.92$, $p < .001$; unergative number: $F(1,23) = 22.38$, $p < .001$). The analysis by type factor revealed that the positivity elicited by the ungrammatical number was larger in the unaccusative predicates than in the unergative ones ($F(1,23) = 6.99$, $p = .015$). Concurrently, the analysis by feature factor showed a marginally significant difference between person and number features in the grammatical unaccusative condition ($F(1,23) = 3.37$, $p = .079$) with a larger positivity for person than for number. Also, a significant difference between the person and number features in the ungrammatical unergative predicates was found indicating larger positivity for the ungrammatical person than for the ungrammatical number feature ($F(1,23) = 7.04$, $p = .014$).

3.3 Summary of the results

Behavioural results show that participants were more accurate and responded faster to ungrammatical sentences than to grammatical ones. They were also more accurate and responded faster to sentences containing person feature manipulations than to sentences containing number feature manipulations.

With regard to predicate types, participants responded faster to unaccusative sentences than unergative ones, and the difference in accuracy between grammatical and ungrammatical sentences was marginally significantly larger in the number condition than in the

person conditions for unaccusatives and significantly larger in the person condition than in the number condition for unergatives.

Regarding ERP responses (see Table 3), all violations elicited a posterior negativity around 300–400 ms. Although the negativity does not have the classic centro-parietal distribution of the N400 (Kutas & Hillyard, 1980), we label it as such following (Mancini et al. 2011; Zawiszewski & Friederici 2009; Zawiszewski et al. 2011; 2016). In all violations, this negativity was followed by a posterior positivity, which we interpreted as a classic P600.

The ERP results showed that the N400 elicited by person violations is overall larger than the one for number violations. Regarding predicate type, ungrammatical unaccusatives elicited a significantly larger P600 over the centro-parietal regions than ungrammatical unergatives. Furthermore, unaccusatives showed a significantly larger P600 in number violations than unergative number violations. Additionally, unergatives revealed a larger P600 for person violations than for number violations.

4 Discussion

The present study had a twofold goal: first, to determine what the processing cost and electrophysiological correlates are for unergative versus unaccusative predicates in Basque. Second, it investigated the processing of person and number phi-features in the context of these two types of predicates. Two hypotheses were tested, the Unaccusative Hypothesis (Perlmutter 1978) and the Feature Separability Hypothesis that we put forth. The UH makes two claims: first it claims that there are two types of intransitive predicates (unaccusatives and unergatives) with different argument structure and syntactic representation, and second it claims they also have different derivations, where the argument of an unaccusative verb undergoes at least one more syntactic computation than the argument of an unergative verb to become subject in the case of Perlmutter (1978) or to receive nominative case in the case of Burzio (1986). The FDH hypothesis claims that person and number are processed and represented differently yielding distinct processing signatures.

Participants were highly accurate, as expected given they were native speakers. They were also faster, as expected, when responding to ungrammatical sentences, and performed with higher accuracy in person feature than in number feature conditions overall, replicating previous findings (Mancini et al. 2011; Zawiszewski et al. 2011; 2016).

Our results reveal significant differences between unaccusatives and unergatives in Basque, both behaviourally and electrophysiologically, thus yielding a new type of evidence in support of the existence of two different types of intransitives in language: unaccusatives that carry theme arguments and unergatives that carry agent arguments. Importantly, Basque participants were faster processing unaccusatives than unergative sentences when performing an acceptability judgement task. This finding suggests that, at least in active-ergative languages like Basque, unaccusatives do not involve movement, as suggested by Levin (1983) and argued by Laka (2006a, b; 2017). Other experimental studies, like Koring et al. (2012) with Dutch, a nominative language, reported the opposite pattern where the unaccusatives took longer than unergatives to process, as a result the authors interpret as evidence that arguments of unaccusatives undergo a further step in the syntactic derivation (promotion to R1 in the case of Perlmutter 1978, working in Relational Grammar, and movement in the case of Burzio 1986, working in Generative Grammar).

Regarding the electrophysiological pattern, we found that unaccusatives and unergatives differ in their processing of phi-features: unaccusatives elicited a larger positivity for number violations than did unergatives and unergatives elicited a larger positivity for person violations than for number violations. Therefore, unaccusative and unergative predicates reveal different electrophysiological responses, specifically related to

phi-features. The pattern of response obtained in unergative sentences, that is, larger positivity for person than for number violations, is the electrophysiological signature found by previous studies analyzing phi features violations in transitive sentences (Nevins et al. 2007; Zawiszewski et al. 2016). In this sense, the ERP signature elicited by unergatives is similar to what has been reported for transitives, a finding that is convergent with the predictions made by the UH regarding the subjects of unergative and transitive sentences, which are “born subjects” and do not involve the promotion of extra movement step required of unaccusatives by the UH.

It is important to bear in mind that the UH was originally formulated based on data from nominative-accusative languages, where the case morphology of all intransitive subjects is the same, namely nominative. Hence, the promotion or movement of the “object born” unaccusative argument is a plausible mechanism to account for its case. In the case of Basque, the case morphology of unergative subjects is ergative, as in transitive subjects, whereas the case morphology of unaccusative subjects is absolutive, as in transitive objects. Levin (1983) was the first to discover this correlation between case morphology and argument structure, showing that the class of unaccusative predicates in this language correlates with absolutive-marked subjects, whereas the class of unergatives has ergative-marked subjects (see also Laka 1993 for a discussion). Since unaccusative subjects do not have the same case as other subjects, Levin speculated that there might be no syntactic movement for unaccusative subjects in Basque, but refrained from claiming it because it violated the principle in Government and Binding that case could not be determined by D-Structure representations (Chomsky 1981). More recently, Laka (2006a, b; 2017) has shown that this correlation is strict, and has argued that case is inherent in Basque, not structural. This would entail no extra derivational step for the sole argument of unaccusative predicates, and thus no extra cost when processing unaccusative sentences as compared to unergative sentences.

A second finding regarding processing differences between unergative and unaccusative predicates concerns phi-features. Recall that unaccusatives showed a significantly larger P600 in number violations, while unergatives showed the opposite pattern, with person violations generating a larger P600 than number violations. This is a novel finding that would have not been detected had the experimental design not considered each feature separately. As it is a novel finding, we will offer a tentative interpretation, and await further replication of similar results for a better grounded understanding. Note that unergatives show the ERP signature associated to violations in transitive sentences, which in turn reveals unergative subjects to be more similar to transitive subjects than to unaccusative subjects, as predicted by the UH. Until a corpus study is carried out in future work, we cannot discard the possibility that this differential sensitivity to the number feature displayed by unaccusatives be a frequency effect, if unaccusatives have third person subjects more frequently than unergatives. In connection to this possibility, speech act participants (speaker and addressee, the two types of arguments that involve *bona fide* person agreement) are more frequently subjects/agents than objects/themes in transitive clauses, a difference that might well carry over to unergatives versus unaccusatives.³

We also tested the Feature Separability Hypothesis that claims that person and number are processed and represented differently, yielding distinct processing signatures. Based on previous research (Chow et al. 2018; Zawiszewski et al. 2016) we expected a similar

³ As suggested by an anonymous reviewer, the disassociation between person and number may be related to differences of predication. Following Landman (2000), it could be the case that the plural subject of an unaccusative construction involves thematic predication, whereas the plural subject of an unergative construction involves a distributed one.

N400 component to be elicited by both person and number violations in both unaccusative and unergative predicates. We also expected to find a larger P600 for violations involving person than for number violations in the late time window (Zawiszewski et al. 2016). Regarding the first expectations, both person and number violations elicited a N400 in both types of predicates, as expected. However, the N400 was larger for person violations than for number violations. This difference can be due to the materials used in each study. Zawiszewski et al. (2016) employed second-person as a baseline for person and number manipulations, while here we used second-person for person manipulations and third-person for number. Hence given the high sensitivity of the methodology used in the current experiment (ERPs), we think that this difference might have led to a different electrophysiological output as the contrast between the person and the number features was already detected at early stages of processing (300–400 ms) indicating that person feature is more salient than number feature.

As concerns the late time-window (400–700 ms), our second expectations were met in that a P600 component was elicited by all violations, as commonly found in the literature on language processing (for a review see Molinaro et al. 2011). Interestingly, the positivity was larger for the ungrammatical person than for the ungrammatical number features in unergative predicates only, replicating the pattern in transitive predicates reported in Zawiszewski et al. (2016).

Altogether, both behavioural and electrophysiological results show that person and number features are processed differently, as indicated by the modulations of both N400 and P600 components.

5 Conclusions

In conclusion, this study shows differences in processing cost regarding unaccusative and unergative predicates and phi-features lending further support both to the UH and to the FDH. Our study provides behavioural and electrophysiological evidence in support of the Unaccusative Hypothesis and the Feature Separability Hypothesis. Behaviorally, we found that participants were faster processing sentences with unaccusative verbs than sentences with unergative verb. This result provides evidence for the first claim in the UH, namely, that unergatives and unaccusatives involve different thematic/structural representations. Interestingly though, it does not provide evidence for the second claim in the UH that unaccusatives involve longer derivations than unergatives, which predicts higher processing costs for unaccusatives than for unergatives. We found the opposite pattern, with unaccusatives being less costly than unergatives. This finding provides support for linguistic analyses that argue that case in Basque is inherent, a direct reflection of theta-role (Laka 2006a, b; Levin 1983) and does not support the hypothesis that case is structural in this language (Ortiz De Urbina 1989). Electrophysiological evidence also shows distinct patterns depending on predicate type, of a novel kind: number violations in the unaccusative condition elicited a larger P600 than number violations in the unergative condition and the positivity was larger for person than for number features in the unergative condition. This finding can be interpreted as a function of prototypicality: unergatives involve agent arguments, highest in animacy and very frequently human where the person feature is most salient, while unaccusatives involve theme arguments, lowest in the animacy scale, with less saliency for the person feature.

Abbreviations

1 = first person, 2/you = second person, 3 = third person, ABS = absolutive, DAT = dative, DET = determiner, ERG = ergative, IMPF = imperfective, PL = plural, SG = singular.

Additional File

The additional file for this article can be found as follows:

- **Supplementary Materials.** The additional file contains the materials used in the experiment. DOI: <https://doi.org/10.5334/gjgl.829.s1>

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Competing Interests

The authors have no competing interests to declare.

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