Processing ergativity: behavioral and electrophysiological evidence☆

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Abstract

So far ergativity has been mostly studied from a language-theoretic perspective and the evidence on how it is processed and represented is rather scarce. In this paper I provide an insight into ergativity from an experimental approach. First, I present an overview of the experimental methods used to investigate ergativity (self-paced reading, event-related potentials and functional magnetic resonance imaging) and next I review studies that investigated behavioral, electrophysiological and neuroanatomical correlates of ergativity in both native and non-native speakers, as well as those focused on the universality of processing strategies in ergative languages. Finally, I also review and discuss the experimental data from works that dealt with syntactic and semantic aspects of ergativity and discuss the implication of the results for future research.

Keywords: ERPs, language processing, ergativity

1. Introduction

Theoretical aspects of ergativity have been widely studied in linguistics (Dixon, 1994; Legate, 2012; Laka & Fernández, 2012; Johns, Massam & Ndayiragije, 2006), but less is known about its representation and processing. Here I present an overview of works that explored ergativity from an experimental perspective. The chapter is organized as follows: I first describe the methodology the studies are based on; next, I analyze the literature on the experimental aspects of ergativity and discuss the findings reported therein; and finally I end by highlighting the implications of the results for further research on ergativity.

1.1. Language processing: a short introduction to research methodology[1]

Experimental studies on ergativity mentioned below are mostly based on two experimental methods: self-paced reading and event-related potentials (ERPs). In the self-paced

☆This research has been supported by the Spanish Ministerio de Economía y Competitividad and the Spanish Ministerio de Ciencia e Innovación (FFI2010-20472; FFI2012-31360); the Basque Government (IT665-13), the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 613465 (AThEME). I would also like to thank Kepa Erdocia, Itziar Laka and Mikel Santesteban for the helpful comments on the previous versions of this manuscript. **Please cite as:** Zawiszewski, A. (to appear). Processing ergativity: behavioral and electrophysiological evidence. In J. Coon, D. Massam, L. Travis, (Eds.) *The Oxford Handbook of Ergativity.* Oxford University Press.

[1] This section focuses only on the methodology used to investigate ergativity. For other approaches, such as the

reading technique participants are required to read sentences (= stimuli) on a computer screen, word-by-word (or phrase-by-phrase) by pressing a button. At each button press only one piece of the sentence (word / phrase) is shown while the rest remains hidden (words are replaced by asterisks, lines or dashes). The task of the participant is to read sentences in a most natural (fast) way and the time he/she spends reading each word (or phrase) is assumed to reflect its processing cost. The subsequent steps when reading the sentence *Yesterday the director arrived late to work* are illustrated by the following example:

1. ********* *** ******** ******* **** ** ****.
   Yesterday *** ******** ******* **** ** ****.
   ********* the ******** ******* **** ** ****.
   ********* *** director ******* **** ** ****.
   ********* *** ******** arrived **** ** ****.
   ********* *** ******** ******* late ** ****.
   ********* *** ******** ******* **** to ****.
   ********* *** ******** ******* **** ** work.

There are different modalities of this technique: the stimuli can be displayed in a *cumulative* or *non-cumulative* way, that is, the items read by the participants may remain revealed while the following ones are being successively uncovered (*cumulative*), or they can be hidden again, meaning that only one segment is visible to the participant at time (*non-cumulative*), as shown in the example (1). The usefulness of the self-paced reading technique has been consistently confirmed in many psycholinguistic experiments – it has been shown, for instance, that temporarily ambiguous, complex or ungrammatical sentences require significantly more time to read than non-ambiguous, simple or grammatical sentences (Mitchell, 1994; Pickering & Van Gompel, 2006; Trueswell & Kim, 1998). Longer reading times are interpreted in terms of larger processing cost of a given structure (word, phrase, sentence, etc.), while shorter reading times reflect smaller processing cost (for a more detailed description, the history of this technique and the discussion, see Jegerski, 2014; Marinis, 2012).

Event-related brain potentials (ERPs) are another technique widely used in order to investigate language processing (for an overview see Kutas & Federmeier, 2007; Kutas, Van Petten & Kluender, 2006). Given their high temporal resolution (milliseconds), they are an appropriate tool to measure the time-course of the processes underlying language comprehension and production. Technically speaking, ERPs are potential changes in the electroencephalogram (EEG), triggered by sensory or cognitive events – in the case of language – words, phrases or sentences (Bornkessel-Schlesewsky & Schlesewsky, 2009; Kaan, 2007). In a standard setup experiment, the EEG is recorded from a set of electrodes (e.g. 32, 64, 128 or more) secured in an elastic cap while a participant is reading or listening to the stimuli. These potential changes are averaged over a large number of trials

eye-tracking, magnetoencephalography (MEG), positron emission tomography (PET) or transcranial magnetic stimulation (TMS), see, for instance Ahlsén (2006); Bornkessel-Schlesewsky & Schlesewsky (2009); Traxler & Gernsbacher (2006).

of the same type yielding the ERP. After the averaging procedure has been performed for each participant, a “grand average” is computed over these individual averages. The final results are interpreted on the basis of these “grand averages”. An example of such a design is illustrated in the Figure 1. The waveforms are distinguished depending on their

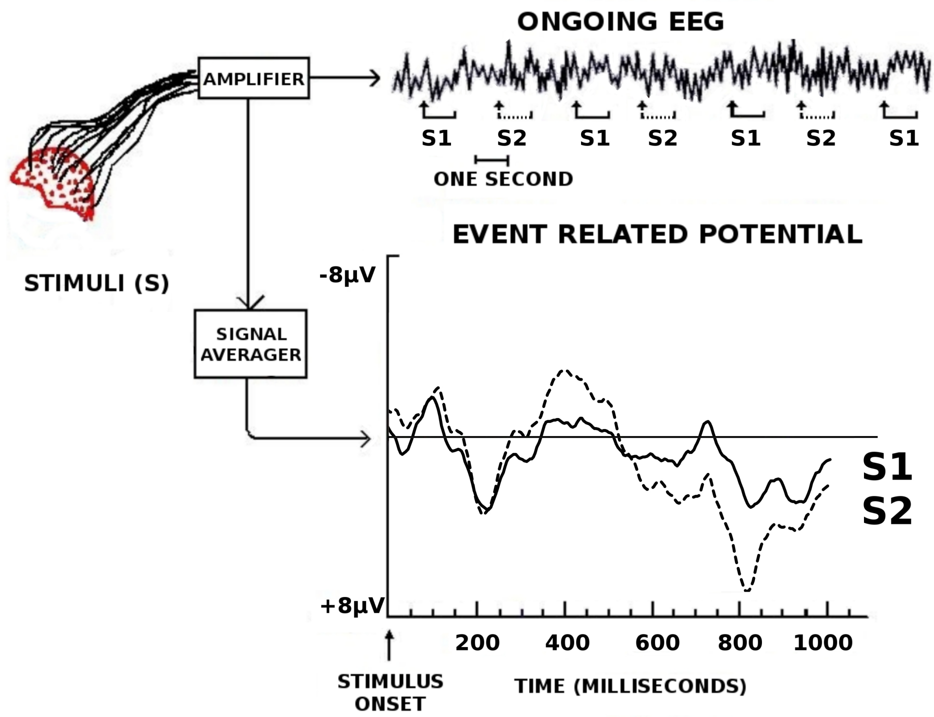

Figure 1: Typical setup of an ERP experiment. Brain activity is recorded and amplified (ongoing EEG) while the participant is presented with visual or auditory stimuli (S). The averaged stimuli (S1 and S2) are represented as voltage changes in microvolts (y-axis) over time (x-axis). Positive potential changes are plotted downward and negative potential changes are plotted upward.

polarity (positive or negative), latency (milliseconds) and topography (scalp distribution) (Bornkessel-Schlesewsky & Schlesewsky, 2009; Kaan, 2007). For instance, as shown in Figure 1, the stimulus of the second type (S2) elicited a larger negativity than the stimulus of the first type (S1) and this difference is largest around 400 milliseconds after the stimulus onset. This type of wave has been labeled a N400. There is also a difference between both waves starting about 600 milliseconds after the stimulus onset, that is, the S2 elicited larger positivity in comparison to the S1. Following the conventional labeling, this waveform is described as a P600. There is also a difference between both waves starting about 600 milliseconds after the stimulus onset, that is, the S2 elicited larger positivity in comparison to the S1. Following the conventional labeling, this waveform is described as a P600.

Several ERP components (waveforms corresponding to specific processes) have been identified in relation to language, but in the subsequent section I will briefly describe the most studied ones: Left Anterior Negativity (LAN), N400 and P600.

LAN, starting about 300 ms after the stimulus onset and observed over the left anterior site of the scalp, has usually been reported in syntactically illicit or complex contexts (Fiebach, Schlesewsky & Friederici, 2002; Friederici, 1995; Münte, Heinze & Mangun, 1993; Neville, Nicol, Barss, Forster & Garrett, 1991), rule violations (Ullman, 2004), as well as in long-distance dependencies (Phillips, Kazanina & Abada, 2005). LAN has been also claimed to index working memory load (Martín-Loeches, Muñoz, Casado, Melcón & Fernández-Frías, 2005) and has been found in semantically reversible sentences (Meltzer & Braun, 2013). However, the nature of this component is still not well known, as many studies failed to identify it in syntactically ungrammatical structures (for more details see Molinaro, Barber, Caffarra & Carreiras, 2014; Molinaro, Barber & Carreiras, 2011; Tanner & Van Hell, 2014; Tanner, 2014).

The second component mentioned above, the N400, is mostly distributed over centro-parietal electrodes and similarly to LAN, starts around 300 ms after the stimulus onset. This negativity has been generally interpreted as a response to semantic, pragmatic or thematic hierarchy violations or in general, as a correlate of non-rule-based lexically stored information (Frisch & Schlesewsky, 2001, 2005; Hagoort, Hald, Bastiaansen & Petersson, 2004; Kutas & Federmeier, 2000; Kutas & Hillyard, 1980; Choudhary, Schlesewsky, Roehm & Bornkessel-Schlesewsky, 2009, discussed in this paper).

Finally, the P600 is a positive component, distributed over the parietal electrodes and starting about 500 ms after the stimulus onset. It has been assumed to reflect reanalysis or integration processes taking place when syntactically ungrammatical, ambiguous or structurally complex information is being parsed (Osterhout & Holcomb, 1992).

Besides self-paced reading and ERPs, the functional magnetic imaging resonance method (fMRI) has been also applied to investigate different aspects of language processing. In a nutshell, the fMRI measures changes of neuronal activity related to an increase and decrease in local blood flow and volume, that is, it captures the changes in brain areas according to the level of oxygenation in the blood (Bornkessel-Schlesewsky & Friederici, 2007; Hunt & Thomas, 2008; Traxler & Gernsbacher, 2006). Given that oxygenated hemoglobin has little effect on the magnetic field while the deoxygenated hemoglobin leads to a higher distortion in the magnetic field, the ratio of oxygenated to deoxygenated blood in a given volume (voxel) is reflected by the so-called "blood oxygen-level dependent contrast" (BOLD) (Bornkessel-Schlesewsky & Schlesewsky, 2009). This BOLD contrast is obtained by subtracting the activation in a control condition from that in an experimental condition. As a result, the pictures of the brain are displayed where the colors reflect the probability associated with the difference between two conditions. In a standard fMRI experiment the participants are presented (either aurally or visually) with stimuli while lying inside the scanner. During the experimental session they are required to perform a task (e.g. reading / listening / speaking / pressing a button / resting, etc.) and at the same time the scanner takes pictures of the brain. Despite its poor temporal resolution, the fMRI method is very accurate to detect where the changes occur. So far researchers have been able to measure and localize some language-related processes, such as the sensitivity of distinct brain regions to the syntactic and semantic processing of speech (Friederici, Meyer

& von Cramon, 2000; Meyer, Friederici & von Cramon, 2000), the representation of the native and second languages in the human cortex (Kim, Relkin, Lee & Hirsch, 1997) or the effects of age of acquisition and proficiency level on neural correlates of grammatical and semantic judgments in bilingual populations (Wartenburger, Heekeren, Abutalebi, Cappa, Villringer & Perani, 2003). When it comes to the specific areas of the brain related to language, the data acquired from many studies suggest that mostly two regions are engaged in both language comprehension and production: left posterior superior temporal gyrus (STG, corresponding to "Wernicke's area") and left inferior frontal gyrus (IFG, corresponding to "Broca's area"). Although these are not the unique brain areas involved during language processes (see, for instance Binder, Frost, Hammeke, Cox, Rao & Prieto, 1997; Booth, Wood, Lu, Houk & Bitan, 2007; Ullman, 2001), in general the findings support the idea that language processing engages mostly a network of (left) fronto-temporal brain regions (Bornkessel-Schlesewsky & Schlesewsky, 2009) (for an overview of the brain basis of language processing see Bornkessel-Schlesewsky & Friederici, 2007; Friederici, 2011; Indefrey, 2007).

2. Ergativity and language processing

The experimental techniques mentioned in the previous section have successfully been used to investigate processes underlying different phenomena in language comprehension, such as verb agreement, case morphology, filler-gap dependencies, word order, and many others (Molinaro *et al.*, 2011; Coulson, King & Kutas, 1998; Fiebach, Schlesewsky & Friederici, 2001; Matzke, Mai, Nager, Rüsseler & Münte, 2002; Erdocia, Laka, Mestres-Missé & Rodríguez-Fornells, 2009). However, until recently, ergativity has not received much attention from a psycholinguistic or experimental perspective. The aim of the present paper is to highlight and bring together the findings of those (few) studies that tackled ergativity from an experimental approach. This topic has been examined from different viewpoints – some works, as Choudhary *et al.* (2009) or Díaz, Sebastián-Gallés, Erdocia, Mueller & Laka (2011), for instance, focused on the electrophysiological correlates of ergativity and tested whether and to what extent the ERP pattern corresponds to that reported previously for nominative-accusative languages. Other studies, such as Carreiras, Duñabeitia, Vergara, de la Cruz-Pavía & Laka (2010) and Polinsky, Gallo, Graff & Kravtchenko (2012) used ergative languages in order to examine the universality of language processing strategies and tested whether subject relative clauses are universally easier to process than object relative clauses, as suggested by previous experimental data on nominative-absolutive languages. Ergative languages have also been employed to test how language processing is influenced by syntactic and semantic cues and which cortical networks are involved in syntactic and semantic computation – as in the case of Dillon, Nevins, Austin & Phillips (2012) and Nieuwland, Martin & Carreiras (2012). Finally, in Zawiszewski, Gutiérrez, Fernández & Laka (2011) ergativity has been used as a testing ground to investigate to what degree native vs. non-native differences in language processing are due to parametric differences between the first (L1) and the second (L2) languages.

2.1. Electrophysiological correlates of ergativity

Choudhary *et al.* (2009) aimed to examine whether the assumption that syntactic processes are reflected by LAN components while lexical-semantic processes are indexed by the N400 holds also for ergative languages such as Hindi, where case marking impacts on semantic interpretation. More precisely, they tested the hypothesis that some N400 components reported previously in the ERP literature (Frisch & Schlesewsky, 2001; Haupt, Schlesewsky, Roehm, Friederici & Bornkessel-Schlesewsky, 2008) might be engendered by syntactic information that is interpretively relevant. To this end, they ran an ERP experiment in which the native speakers of Hindi listened to grammatical and ungrammatical sentences and performed a grammaticality judgment task. The participants were presented with the following type of sentences[2]:

2. a. shikshak maalii-ko **dekh-taa** hai
   teacher-NOM gardener-ACC see-IPFV-3SG.M AUX
   'The teacher sees the gardener.'
   b. shikshak-ne maalii-ko ***dekh-taa** hai
   teacher-ERG gardener-ACC see-IPFV-3SG.M AUX
   'The teacher sees the gardener.'
   c. shikshak maalii-ko ***dekh-aa** hai
   teacher-NOM gardener-ACC see-PFV-3SG.M AUX
   'The teacher has seen the gardener.'
   d. shikshak-ne maalii-ko **dekh-aa** hai
   teacher-ERG gardener-ACC see-PFV-3SG.M AUX
   'The teacher has seen the gardener.'

In Hindi, an ergative-marked argument (2b and 2d) receives an agentive reading in a perfective aspect while a nominative-marked argument can be interpreted as an actor of a two-participant event in an imperfective aspect, or an actor or undergoer in a one-participant event (e.g. *the teacher is ill*). Choudhary *et al.* (2009) follow Butt & King (2005) in the assumption that subjects are assigned nominative case by default while the ergative is a "semantic" case that is assigned under more restricted circumstances. The experimental design shown in the example (2) allowed the authors to investigate whether the response elicited by the violation would be modulated by the misapplication of a default (nominative) vs. a non-default (ergative) rule. They hypothesized that if the violation of rule-based linguistic knowledge lead to LAN effects, both ungrammatical conditions should yield LANs as compared to their grammatical counterparts (2b vs. 2a = 2d vs. 2c). However, if the ERP correlate of a violation depended on the type of linguistic rule (default vs. non-default), the incorrect usage of the nominative (default) (2c) should elicit a LAN in comparison to (2d), while the incorrect usage of the ergative (non-default) (2b) would yield a N400 in comparison to (2a). Finally, if the rule-based information were interpretatively important, the corresponding violations should yield a N400. According

[2]The following abbreviations are used throughout the text: NOM – nominative, ACC – accusative, ERG – ergative, ABS – absolutive, IPFV – imperfective, PFV – perfective, FUT – future, 3 – 3rd person, M – masculine, AUX – auxiliary, SG – singular, PL – plural, S – subject, O – object, e – gap, OBL – oblique, LOC – locative, PRTCP – participle, GER – gerund, AGR – agreement suffix.

to the literature, the authors also expected to find a P600 for both violation conditions (Osterhout & Holcomb, 1992).

Electrophysiological results of the experiment revealed a N400 for both types of violations, followed by a broad positivity (P600) in the ungrammatical ergative as compared to the grammatical nominative condition (2b vs. 2a), but no such a positivity was observed when comparing the ungrammatical nominative condition to the ergative grammatical condition (2c vs. 2d). Importantly, the N400 effect was larger for the ungrammatical ergative than for the ungrammatical nominative condition suggesting that the interpretative problem caused by the rule misapplication was greater in the former than in the latter case. These findings lend support to the third hypothesis put forward by the authors, according to which syntactic processes that impact on semantic interpretation can elicit N400 effects. Also, the P600 elicited by the ungrammatical ergative condition as compared to the grammatical nominative condition suggests that late positive ERP effects may be highly sensitive to rule exceptions, that is, to occur only in response to principled incompatibilities between grammatical features such as case and aspect. In sum, these findings indicate that the dichotomy between the rule-based and lexically stored information is not necessarily reflected by a LAN vs. N400 components. Rather, the ERP signature is determined by the type of syntactic information where formal rule violations such as subject-verb agreement lead to a LAN, while interpretatively relevant rule violations, as subject case-marking in Hindi, yield a N400. Neural language architecture was also the main topic studied by Díaz *et al.* (2011) who investigated the cross-linguistic validity of electrophysiological correlates of morphosyntactic processing in Basque. During the ERP experiment native speakers of Basque listened to grammatical and ungrammatical sentences (double case violations) and were required to respond whether the sentences were grammatical or not. The sample of the materials is shown in (3):

3. a. Mikelen arreb-ek **egunkari-a** saski-an ekarri dute kiosko-tik.
   Mikel's sister-ERG$_{\text{PL}}$ newspaper-ABS$_{\text{SG}}$ basket-in brought have kiosk-from.
   b. Mikelen arreb-ek ***egunkari-ek** saski-an ekarri dute kiosko-tik.
   Mikel's sister-ERG$_{\text{PL}}$ newspaper-ERG$_{\text{PL}}$ basket-in brought have kiosk-from.
   'Mikel's sisters have brought the newspaper in a basket from the kiosk.'

While (3a) is grammatical, (3b) is not because the object of the sentence *egunkariek* 'newspapers' bears the same case mark *-ek* as the subject *arrebek* 'sisters', yielding ungrammaticality. Double case violations tested previously in other (nominative-accusative) languages elicited a centro-parietal negativity (N400) followed by the P600 component (Frisch & Schlesewsky, 2001; Mueller, Hirotani & Friederici, 2007; Frisch & Schlesewsky, 2005). Based on this evidence the authors aimed to examine whether the ERP correlates of ergative case processing are similar to those found in nominative languages. Behavioral results revealed no differences in accuracy between the grammatical and the ungrammatical conditions (95.1% vs. 95.2%). In comparison to the grammatical sentences, double violations elicited larger positivity (P600) between 400 and 1250 ms at the critical word position (*egunkaria* 'newspaper- ABS$_{\text{SG}}$' vs. *egunkariek* 'newspaper-ERG$_{\text{PL}}$'). In this sense, the results are similar to those reported for nominative languages (Frisch & Schlesewsky, 2001; Mueller, Hahne, Fuji & Friederici, 2005). The authors did not replicate the N400 reported in Hindi by Choudhary *et al.* (2009) and argue that the differences between the results might be accounted for either by the differences between Hindi and Basque (Hindi is a split-ergative language while Basque is not) or by the type of materials used in both experiments. In sum, according to the authors, the presence of the P600 component supports the view that ERP signatures engaged in the detection of case violations are similar across languages and do not depend on the argument alignment type.

2.2. Universal processing strategies and ergativity: subject vs. object relative clauses

Among the works that have tested universal processing strategies (Kwon, Kluender, Kutas & Polinsky, 2013; Demiral, Schlesewsky & Bornkessel-Schlesewsky, 2008) Carreiras *et al.* (2010) were the first who took advantage of ergativity to investigate whether subject relative clauses (SR) are universally easier to process than object relative clauses (OR), as suggested by previous results on the topic (Friederici, Mecklinger, Spencer, Steinhauer & Donchin, 2001; King & Kutas, 1995; Weckerly & Kutas, 1999; Kwon *et al.*, 2013). To this purpose Basque, an ergative, head-final language with pre-nominal relative clauses, spoken in the northeastern Spain and southwestern France was used as a testing ground and the authors used both self-paced reading moving window (Experiments 1 and 2) and ERP techniques (Experiment 3). The following conditions were compared:

4. a. Irakasleak aipatu dituen ikasleak lagunak **ditu**. (SR)
   [e_1 irakasle-ak aipatu ditu-en] ikasle-a-k_1 lagun-ak ditu
   [e_1 teacher-pl mentioned has-rel] student-sg-S_1 friend-pl has
   'The student that mentioned the teachers has friends'
   b. Irakasleak aipatu dituen ikasleak lagunak **dira**. (OR)
   [irakasle-a-k e_1 aipatu ditu-en] ikasle-ak_1 lagun-ak dira
   [teacher-sg-S e_1 mentioned has-rel] student-pl_1 friend-pl are
   'The students that the teacher mentioned are friends'

Both sentences are disambiguated toward a SR or OR interpretation at the auxiliary verb position. The results of the first experiment showed that OR sentences were easier to read than SR sentences, that is, the participants needed less time (115 ms) to read the auxiliary verb *dira* 'are' than the verb *ditu* 'has'. In the second experiment the authors used the modified version of the stimuli from the previous study in order to make sure that the effects were not due to sentence final wrap-up effects (Just & Carpenter, 1980) and obtained very similar results: ORs were easier to process than SRs (a 109 ms difference). Finally, the aim of the last experiment was to provide more detailed evidence on the time-course of SR vs. OR processing by using ERPs. The data revealed significant differences between the conditions at the critical word position (*dira* 'are' vs. *ditu* 'has'), that is, the waves elicited by subject relative clauses were more positive than those elicited by the object relative clauses. Given its latency and distribution, this effect was labeled as a P600.

According to the authors, the advantage in processing object relatives over subject relatives found in Basque may be accounted by the fact that if morphological unmarkedness provides a processing advantage in language (Badecker & Kuminiak, 2007; Laka, 2012), then differences would be expected for ergative languages as compared to languages with the nominative-accusative case system. More precisely, in Basque objects are the unmarked form and the (transitive) subjects are the marked one while in other tested languages (English, Spanish, Japanese, Korean) objects are the marked class and the subjects the unmarked one. This typological difference might thus explain the processing advantage reported for object relatives in Basque, in contrast to previous findings who revealed subject relatives to be processed with a greater ease than object relatives(see also Erdocia *et al.*, 2009, for a similar advantage of object over subject processing in canonical and non-canonical sentences in Basque). Altogether, these findings indicate that rather than being universal, subject / object processing strategies are impacted by language specific aspects of grammar, in this case ergative-absolutive vs. nominative-accusative case alignment.

Polinsky *et al.* (2012) (for an extended description, materials and discussion see Longenbaugh and Polinsky, this volume) provided another piece of evidence in order to clarify whether or not SRs are universally easier to process than ORs by testing subject preference and ergativity in Avar, a language spoken in the northwest and central regions of the Republic of Dagestan. The authors used the self-paced reading (moving window) method to investigate how native speakers of Avar process ergative subject, absolutive object and absolutive subject relative clauses. The main aim of this study was to investigate whether subject gaps are easier to process than object gaps (regardless of the case form) or, whether the processing preference is driven by surface case considerations. Both hypotheses make different predictions: according to the former ergative subject and absolutive subject relative clauses should be easier to process than object absolutive clauses, whereas the latter predicts ergative subject vs. abolutive subject and absolutive object differences differences.

Self-paced reading times revealed no significant effect of case marking at the head noun region. Only a marginally significant effect of grammatical function was found, that is, the intransitive subject was read faster than the ergative subject and the absolutive object, and these two were read at similar rate. The same effects were observed at the subsequent region. In sum, in light of these results Avar does not show a processing difference between the ergative subject and the absolutive object. The authors interpret these data by arguing that processing strategies in Avar are driven by two preferences: the one for subject relatives and the other for morphologically cued gaps. The former makes the ergative and absolutive subject gap to be processed easier than the absolutive object gap while in the latter the ergative case serves as a cue which allows the parser to predict the structure of the clause (the missing absolutive object), making thus the absolutive object gap processing easier. Since these two preferences cancel each other out, the reading times for the ergative subjects and absolutive object relative clauses are similar. In sum, in light of these data the question whether or not subject relative clauses are easier to process than object relative clauses in Avar and in other ergative languages remains open and needs to be further tested (but note that the interpretation of the results is based on a null effect, and should be taken with caution).

2.3. Syntactic vs. semantic processing and ergativity

Similarly to Choudhary *et al.* (2009), Dillon *et al.* (2012) also investigated the electrophysiological correlates of ergativity in Hindi, but under a slightly different approach. The main objective of this study was to examine the effects of syntactic and semantic cues on tense / aspect processing. During the ERP experiment, native speakers of Hindi read sentences word-by-word on the screen and had to decide whether they were grammatical or not. The shortened version of the materials used by the authors is presented in (5):

5. a. Haalaanki us bunkar-ne (...) **bun-aa**, (...)
   although that weaver-ERG weave-PFV
   'Although that weaver wove (...), (...)'

   b. Haalaanki us bunkar-ne (...) **bun-e-gaa**, (...)
   although that weaver-ERG weave-AGR-FUT
   'Although that weaver will weave (...), (...)'

   c. Haalaanki pichle shaam (...) **gir-aa**, (...)
   although last night fall-PFV
   'Although last night (...) fell, (...)'

   d. Haalaanki pichle shaam (...) **gir-e-gaa**, (...)
   although last night fall-AGR-FUT
   'Although last night (...) will fall, (...)'

In the first two examples (5ab), the cue for the tense / aspect of the verb is provided by the ergative case marker while in 6cd the tense / aspect of the verb is cued by the semantic information of the adverb. ERPs to grammatical and ungrammatical verb forms were measured and the results showed that in the conditions where syntactic cues predicted verbal morphology (6ab), the tense / aspect violations elicited a right-lateralised anterior negativity (RAN) within 300 – 500 ms time window, followed by a P600 component. In contrast, in the context where verbal morphology was predicted by semantic cues (6cd), the ungrammaticality yielded an early posterior negativity (200 – 400 ms) and a small P600 effect (600 – 800 ms). The comparison between both syntactic and semantic conditions revealed that the P600 was significantly larger and more broadly distributed in the syntactic (ergative) cue conditions than in the semantic (adverbial) cue conditions. According to the authors, these qualitative and quantitative differences in the response to the two types of cues indicate that the processing system is able to rapidly recognize and distinguish between different potential error causes and also suggest that the predictions generated by ergative case marking are stronger than those induced by the semantic cue condition.

Another study that focused on syntactic vs. semantic aspects of language processing in an ergative language is that of Nieuwland *et al.* (2012) who used event-related functional magnetic resonance imaging (fMRI)[3] to investigate the cortical networks involved in ergative case, number agreement and semantic processing in Basque. In this study native speakers of Basque read sentences shown in (6ab) word-by-word in the scanner and judged their grammaticality by pressing a corresponding button.

6. a. Gizon-a-k lehiatila-n jaso dit-u **sarrer-ak** goizean
   Man-the-ERG$_{SG}$ box office-loc received them-root-he ticket-the-ABS$_{PL}$ morning

   b. Gizon-a-k lehiatila-n jaso dit-u ***sarrer-ek** goizean

[3] For a more detailed description of the method and its use in psycholinguistics, see for instance Bornkessel-Schlesewsky & Friederici (2007); Bornkessel-Schlesewsky & Schlesewsky (2009).

Man-the-ERG$_{SG}$ box office-loc received them-root-he ticket-the-ERG$_{PL}$ morning

c. Gizon-a-k lehiatila-n jaso dit-u ***sarrer-a** goizean

Man-the-ERG$_{SG}$ box office-loc received them-root-he ticket-the-ABS$_{SG}$ morning

'The man at the box office has received the tickets in the morning.'

d. Gizon-a-k lehiatila-n jaso dit-u ***begi-a-k** goizean

Man-the-ERG$_{SG}$ box office-loc received them-root-he eye-the-ABS$_{PL}$ morning

'The man at the box office has received the eyes in the morning.'

(6a) is grammatical, as the morphology of both the subject (gizonak 'the man') and the object (*sarrerak* 'tickets') is correctly reflected in the auxiliary verb. On the contrary, (6b) is ungrammatical because it contains an incorrectly (ergative) case-marked object *sarrerek* 'tickets' instead of the grammatical absolutive object *sarrerak* 'tickets'. In (6c) the verb *ditu* 'them-root-he' does not agree in number with the object *sarrera* 'ticket' yielding ungrammaticality and in (6d) the object *begiak* 'eyes' does not fit in the previous context, making the sentence semantically implausible. This design allowed the authors to compare the areas of the brain involved in processing case (6b vs. 6a) and number agreement morphology (6c vs. 6a) on the one hand, and semantic processing (6d vs. 6a) on the other hand.

Results from the grammaticality judgment task showed that participants responded more accurately and faster to ergative case violations than to other conditions (correct control, number agreement violations, semantic violations). As for the neuroanatomical correlates of the phenomena tested in the experiment, besides small differences, the overlapping neural circuits (parietal regions and left / right inferior parietal gyri) were involved in processing both the ergative case and the number agreement suggesting that similar cortical networks are recruited during these processes. In contrast, different brain regions (left /right anterior prefrontal gyri) were involved in semantic processing, indicating that syntactic and semantic processing rely on qualitatively different brain circuits. All in all, the data suggest that the neural consequences of a thematic problem generated by an ungrammatical use of ergative case are different from those engendered by a thematic problem in which an argument cannot bear the thematic role it is assigned.

2.4. Ergativity and native vs. non-native language processing

In addition to native populations, ergativity has also been investigated among non-native speakers. Zawiszewski *et al.* (2011), for instance, used ERPs to examine the extent to which parametric differences between the first (L1) and the second (L2) language of the bilinguals influence the way the L2 is processed. To this purpose Basque-Spanish and Spanish-Basque bilingual populations were tested. Given that Basque and Spanish diverge with respect to the case system – Basque is ergative-absolutive while Spanish is nominative-accusative – the authors tested how native speakers of Basque and highly proficient Spanish-Basque bilinguals (L2 learned before the age of 3) deal with grammatical and ungrammatical sentences, as these shown in the examples (7ab):

7. a. Goiz-ean ogia erosi dut **ni-k** denda-n.

Morning-in bread bought have I-ERG shop-in

b. Goiz-ean ogia erosi dut ***ni** denda-n.

Morning-in bread bought have I-ERG shop-in

'This morning I bought bread in the shop.'

While (7a) is grammatical, in (7b) the subject of the sentence *ni* 'I' lacks the ergative marker (-*k*), yielding ungrammaticality. The participants were required to read the sentences and to judge (by pressing a corresponding button) whether the sentences were grammatical or not. Behavioral results showed that the non-native speakers were significantly less accurate than the native speakers (85% vs. 97%). The electrophysiological pattern also differed between both populations: among the L1 speakers of Basque the ungrammaticality elicited a N400 followed by a P600 component (cf. Choudhary *et al.*, 2009, for similar findings) whereas in the L2 speakers only a N400 was found (see Figure 2). These

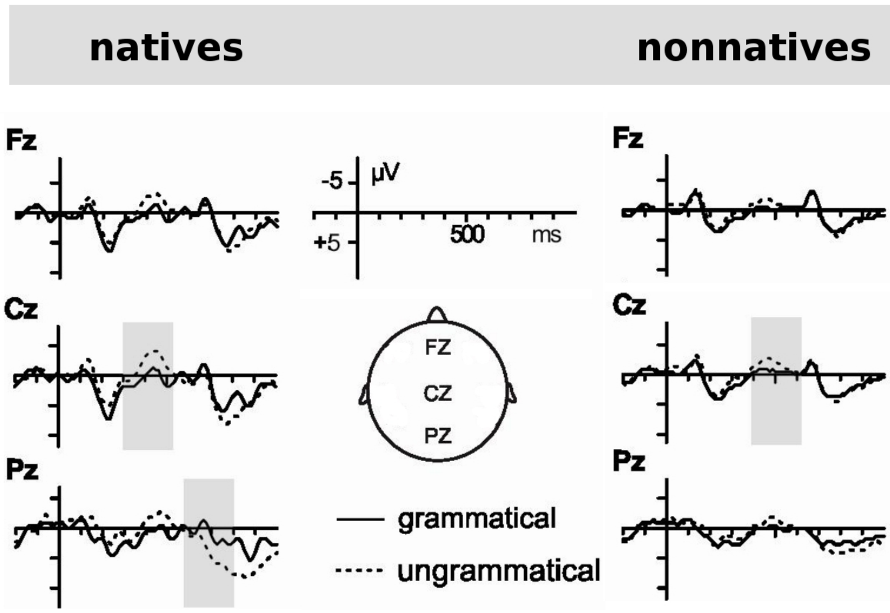

*Figure 2: The ERP pattern elicited by the ergative case violations (dashed line) as compared to the grammatical sentences (continuous line) among the native speakers (left side of the panel) and the non-native speakers of Basque (right side of the panel). The waves correspond to the critical word position (nik 'I' vs. *ni 'I'). Negativity is plotted upward. The N400 component (similar in both groups) can be observed at the Cz electrode between 300 and 500 ms after the stimulus onset. The P600 component (more positive wave for the ungrammatical than for the grammatical condition) is present in the native group (Pz electrode, left side), but absent in the non-native group (500 – 800 ms time window).*

results indicate that despite high proficiency and early L2 acquisition onset, the non-native speakers of Basque process the ergative case differently from the native speakers, as shown by both the behavioral and electrophysiological data. This, in turn, suggests that native vs. non-native differences obtain if a syntactic parameter of the non-native grammar diverges from the native grammar (see also Chen, Shu, Liu, Zhao & Li, 2007; Ojima, Nakata & Kakigi, 2005, for verb agreement; Weber-Fox & Neville (1996) for subjacency effects).

In sum, these results reveal that the case parameter is an important factor to be taken into account when comparing native and non-native language processing, particularly in those circumstances where it takes a different value in the bilinguals' first and second languages.

3. Discussion and Conclusion

The purpose of the present paper was to present those studies that approached ergativity from a psycholinguistic perspective. The work by Choudhary *et al.* (2009) showed that the violations of rule-based linguistic knowledge do not necessarily lead to LAN effects. Rather, as suggested by the evidence from Hindi, the ERP pattern triggered by the violations depends on whether the violated grammatical rule is interpretatively relevant or not. In other words, the processing of rule-based linguistic knowledge correlates with an N400 when the misapplication of the rule has interpretative consequences, otherwise a LAN is expected as response to the violations of rules which do not induce comprehension problems. The results of this study were fully corroborated by the ERP data from native speakers of Basque (Zawiszewski *et al.*, 2011), where ergative case violations elicited a similar N400 – P600 pattern to that reported for Hindi. In that sense, it seems that the violations of ergative case yield larger interpretative problems than case violations in nominative-accusative languages, where usually left anterior negativities followed by the P600 component have been found (e.g. Coulson *et al.*, 1998). On the other hand, the late positivity reported by Díaz *et al.* (2011) for double ergative case violations in Basque, found also in Choudhary *et al.* (2009) and Zawiszewski *et al.* (2011) indicates that repair and reanalysis processes do not depend on case alignment and are crosslinguistically uniform.

On the other hand, the experimental data from subject and object relatives reviewed here seem to cast doubts on the theories claiming subject relative clauses to be universally easier to process than object relatives. As shown by Carreiras *et al.* (2010) and contrary to previous findings in nominative-accusative languages, in Basque the object relatives are processed with greater ease than the subject relatives. As argued by the authors, a plausible explanation of this finding lies on the fact that if morphologically unmarked arguments require less effort than marked arguments to be processed, subject relatives are processed faster than object relatives in nominative-accusative languages, as subjects are morphologically unmarked while objects are marked. In contrast, in ergative languages a different pattern is expected: given that the objects are an unmarked class, object relatives are easier to process than transitive (marked) subject relatives. This, in turn, challenges the hypothesis on the universality of subject over object preference and suggests that subject / object processing strategies may vary depending on the case alignment. These data are similar to those reported by Gutiérrez-Mangado (2011) who revealed that 4 and 6 year children respond to ORs with greater accuracy than to SRs when performing a comprehension task in Basque. Likewise, Munarriz, Ezeizabarrena & Gutiérrez-Mangado (2015) tested a Spanish-Basque Broca's aphasic bilingual patient and reported higher accuracy in a comprehension task for ORs than for SRs in Basque. However, these findings were not confirmed by Polinsky *et al.* (2012) who did not observe a similar tendency in Avar. Although the authors explain the lack of contrast between subject and object relatives in terms of two (opposite) processing preferences which cancel each other out, further evidence is still needed in order to confirm either theory (for the discussion on the topic see also Laka, 2012).

Within the third group of studies mentioned here Dillon *et al.* (2012) measured how verb processing is modulated by syntactic (ergative-marked arguments) or semantic (tense adverbials) information in Hindi. With respect to the early effects, the negativity elicited by semantic cues was similar to a classic N400 component, while the ungrammatical use of the ergative marking yielded a right anterior negativity (RAN). The latter result differs significantly from previous evidence on ergativity violations (Choudhary *et al.*, 2009; Díaz *et al.*, 2011; Zawiszewski *et al.*, 2011). Although the authors interpret this negativity as an index of processing demands during the resolution of the morphological dependencies between the verb and its arguments (see also Ueno & Kluender, 2009, for a similar reasoning when dealing with anomalies during the processing of Japanese wh-questions), it is not clear why similar manipulations elicited an N400 in the study by Choudhary *et al.* (2009). The differences could be accounted by the type of materials used in both studies (simple vs. complex sentences) or to the presentation modality (aural vs. visual), but more detailed research is needed in order to clarify this issue. Importantly, Dillon *et al.* (2012) found also a P600 component as response to the ungrammatical use of ergative morphology. This finding is consistent with all the ERP studies where ergativity was manipulated and indicate that late (repair / reanalysis) processes are crosslinguistically similar and do not depend on a specific case alignment setting.

Furthermore, the study by Nieuwland *et al.* (2012) provides additional evidence on the neuroanatomical correlates of ergativity. The authors contribute by investigating the cortical networks involved in case, agreement and semantic processing, and thus, shed more light on the mechanisms involved during these operations. The fMRI data support, to a large extent, previous findings in fMRI literature (Kaan & Swaab, 2003; Kuperberg, Holcomb, Sitnikova, Greve, Dale & Caplan, 2003): neural circuits associated with syntactic processing differ significantly from those engaged during semantic processing. Also, in the light of the neuroimaging evidence, case and agreement violations draw upon overlapping neural circuits suggesting that similar brain regions are involved during case and agreement comprehension. These findings are largely compatible with the ERP data on case and agreement violations: usually both manipulations yield similar biphasic ERP pattern – the P600 preceded by a negative component. In sum, the fMRI evidence together with the ERP findings reveal that when dealing with ungrammaticality, processing mechanisms are similar across languages.

In addition, the study by Zawiszewski *et al.* (2011) demonstrates how ergativity is processed by the native speakers and the non-native high-proficiency L2 bilinguals. While both groups of speakers were tested when processing ergative case violations in Basque, only the native group displayed a N400 – P600 pattern. The non-natives showed a N400 but no P600 effect, despite their high proficiency and early age of acquisition (AoA) onset (3 years). These differences are attributed to both the delay in L2 acquisition and to the parametric variation in case alignment setting between the L1 and the L2 of the non-native group. In other words, according to the authors, native vs. non-native effects obtain even at high level of proficiency and relatively low AoA only for those aspects of grammar which substantially differ between the L1 and the L2, such as case setting, whereas other, superficially divergent morphological aspects of language such as verb agreement do not seem to be sensitive to age of exposure.

Summarizing, the experimental evidence on ergativity reported here provides a more complete picture of language processing architecture. In general, the electrophysiological pattern found when processing ergative case violations corresponds to that revealed during similar case violations in accusative languages (Frisch & Schlesewsky, 2001, 2005) and thus indicate that the mechanisms underlying language comprehension are comparable across languages with a different case morphology. Also, the findings reported in Carreiras *et al.* (2010) and Polinsky *et al.* (2012) shed more light on the subject vs. object processing strategies in ergative languages and show that the theories claiming subjects to be universally easier to process than objects need to be reconsidered by taking into account languages with different typologies and characteristics in order to successfully explain general principles of language processing mechanisms.

References

Ahlsén, E. (2006). *Introduction to Neurolinguistics*. John Benjamins Publishing Company, Amsterdam/Philadelphia.

Badecker, W. & Kuminiak, F. (2007). Morphology, agreement and working memory retrieval in sentence production: Evidence from gender and case in Slovak. *Journal of Memory and Language*, **56**, 65–85.

Binder, J., Frost, J., Hammeke, T., Cox, R., Rao, S. & Prieto, T. (1997). Human brain language areas identified by functional magnetic resonance imaging. *The Journal of Neuroscience: The Official Journal of the Society for Neuroscience*, **17**, 353–362.

Booth, J.R., Wood, L., Lu, D., Houk, J.C. & Bitan, T. (2007). The role of the basal ganglia and cerebellum in language processing. *Brain Research*, **1133**, 136–144.

Bornkessel-Schlesewsky, I. & Friederici, A.D. (2007). Neuroimaging studies of sentence and discourse comprehension. In M. Gaskell, ed., *The Oxford Handbook of Psycholinguistics*, 407–424, Oxford University Press, Oxford.

Bornkessel-Schlesewsky, I. & Schlesewsky, M. (2009). *Processing Syntax and Morphology: A neurocognitive perspective*. Oxford University Press, Oxford, UK.

Butt, M. & King, T.H. (2005). The status of Case. In V. Dayal & A. Mahajan, eds., *Clause Structure in South Asian Languages*, Springer, Berlin.

Carreiras, M., Duñabeitia, J., Vergara, M., de la Cruz-Pavía, I. & Laka, I. (2010). Subject relative clauses are not universally easier to process: Evidence from Basque. *Cognition*, **115**, 79–92.

Chen, L., Shu, H., Liu, Y., Zhao, J. & Li, P. (2007). ERP signatures of subject–verb agreement in L2 learning. *Bilingualism: Language and Cognition*, **10**, 161–174.

Choudhary, K.K., Schlesewsky, M., Roehm, D. & Bornkessel-Schlesewsky, I. (2009). The N400 as a correlate of interpretively relevant linguistic rules: evidence from Hindi. *Neuropsychologia*, **47**, 3012–3022.

Coulson, S., King, J. & Kutas, M. (1998). Expect the unexpected: Event-related brain response to morphosyntactic violations. *Language and Cognitive Processes*, **13**, 21–58.

Demiral, S.B., Schlesewsky, M. & Bornkessel-Schlesewsky, I. (2008). On the universality of language comprehension strategies: evidence from Turkish. *Language*, **106**, 484–500.

Dillon, B., Nevins, A., Austin, A.C. & Phillips, C. (2012). Syntactic and semantic predictors of tense in Hindi: An ERP investigation. *Language and Cognitive Processes*, **27**, 313–344.

Dixon, R.M.W. (1994). *Ergativity*. Cambridge University Press, Cambridge.

Díaz, B., Sebastián-Gallés, N., Erdocia, K., Mueller, J. & Laka, I. (2011). On the cross-linguistic validity of electrophysiological correlates of morphosyntactic processing: A study of case and agreement violations in Basque. *Journal of Neurolinguistics*, **24**, 357–373.

Erdocia, K., Laka, I., Mestres-Missé, A. & Rodríguez-Fornells, A. (2009). Syntactic complexity and ambiguity resolution in a free word order language: behavioral and electrophysiological evidences from Basque. *Brain and Language*, **108**, 1–17.

Fiebach, C.J., Schlesewsky, M. & Friederici, A.D. (2001). Syntactic working memory and the establishment of filler-gap dependencies: insights from ERPs and fMRI. *Journal of Psycholinguistic Research*, **30**, 321–338.

Fiebach, C.J., Schlesewsky, M. & Friederici, A.D. (2002). Separating syntactic integration cost during parsing: The processing of German WH-questions. *Journal of Memory and Language*, **47**, 250–272.

Friederici, A., Mecklinger, A., Spencer, K., Steinhauer, K. & Donchin, E. (2001). Syntactic parsing preferences and their on-line revisions: a spatio-temporal analysis of event-related brain potentials. *Cognitive Brain Research*, **11**, 305–323.

Friederici, A.D. (1995). The time course of syntactic activation during language processing. a model based on neuropsychological and neurophysiological data. *Brain and Language*, **50**, 259–281.

Friederici, A.D. (2011). The brain basis of language processing: from structure to function. *Physiological Reviews*, **91**, 1357–1392.

Friederici, A.D., Meyer, M. & von Cramon, D. (2000). Auditory language comprehension: an event-related fMRI study on the processing of syntactic and lexical information. *Brain and Language*, **74**, 289–300.

Frisch, S. & Schlesewsky, M. (2001). The N400 reflects problems of thematic hierarchizing. *Basic and Clinical Neurophysiology*, **12**, 3391–3394.

Frisch, S. & Schlesewsky, M. (2005). The resolution of case conflicts from a neurophysiological perspective. *Cognitive Brain Research*, **25**, 484–498.

Gutiérrez-Mangado, M.J. (2011). Children's comprehension of relative clauses in an ergative language: The case of Basque. *Language Acquisition*, **18**, 176–201.

Hagoort, P., Hald, L., Bastiaansen, M. & Petersson, K. (2004). Integration of word meaning and word knowledge in language comprehension. *Science*, **304**, 438–441.

Haupt, F.S., Schlesewsky, M., Roehm, D., Friederici, A.D. & Bornkessel-Schlesewsky, I. (2008). The status of subject–object reanalyses in the language comprehension architecture. *Journal of Memory and Language*, **51**, 54–96.

Hunt, R.H. & Thomas, K.M. (2008). Magnetic resonance imaging methods in developmental science: a primer. *Development and Psychopathology*, **20**, 1029–1051.

Indefrey, P. (2007). Brain-imaging studies of language production. In M. Gaskell, ed., *The Oxford Handbook of Psycholinguistics*, 547–564, Oxford University Press.

Jegerski, J. (2014). Self-paced reading. In J. Jegerski & B. Van Petten, eds., *Research methods in second language psycholinguistics*, 20–49, Routledge, New York.

Johns, A., Massam, D. & Ndayiragije, J. (2006). *Ergativity: Emerging issues. Studies in natural language and linguistic theory (Vol. 65).* Dordrecht, Berlin: Springer.

Just, M. & Carpenter, P. (1980). A theory of reading: from eye fixations to comprehension. *Psychological Review*, **87**, 329–354.

Kaan, E. (2007). Event-related potentials and language processing: A brief overview. *Language and Linguistics Compass*, **1**, 571–591.

Kaan, E. & Swaab, T. (2003). Repair, revision, and complexity in syntactic analysis: An electrophysiological differentiation. *Journal of Cognitive Neuroscience*, **15**, 98–110.

Kim, K., Relkin, N., Lee, K.M. & Hirsch, J. (1997). Distinct cortical areas associated with native and second languages. *Nature*, **388**, 171–174.

King, J. & Kutas, M. (1995). Who did what and when? Using word- and clause-level ERPs to monitor working memory usage in reading. *Journal of Cognitive Neuroscience*, **7**, 376–395.

Kuperberg, G., Holcomb, P., Sitnikova, T., Greve, D., Dale, A. & Caplan, D. (2003). Distinct patterns of neural modulation during the processing of conceptual and syntactic anomalies. *Journal of Cognitive Neuroscience*, **15**, 272–293.

Kutas, M. & Federmeier, K. (2000). Electrophysiology reveals semantic memory use in language comprehension. *Trends in Cognitive Sciences*, **4**, 463–470.

Kutas, M. & Federmeier, K. (2007). Event-related brain potential (ERP) studies of sentence processing. In M. Gaskell, ed., *The Oxford Handbook of Psycholinguistics*, 385–406, Oxford University Press, Oxford.

Kutas, M. & Hillyard, S. (1980). Reading senseless sentences: Brain potentials reflect semantic incongruity. *Science*, **207**, 203–205.

Kutas, M., Van Petten, C. & Kluender, R. (2006). Psycholinguistics Electrified II (1994-2005). In M. Traxler & M. Gernsbacher, eds., *Handbook of Psycholinguistics*, 659–724, Elsevier, New York.

Kwon, N., Kluender, R., Kutas, M. & Polinsky, M. (2013). Subject/object processing asymmetries in korean relative clauses: Evidence from ERP data. *Language*, **89**, 537–585.

Laka, I. (2012). Merging from the temporal input: on subject-object asymmetries and an ergative language. In R. Bervick & M. Piattelli-Palmarini, eds., *Rich Grammars from Poor Inputs*, 1–21, Oxford University Press, Oxford.

Laka, I. & Fernández, B. (2012). *Accounting for ergativity. Special issue of Lingua, vol.122 (3)*. Elsevier.

Legate, J. (2012). Types of ergativity. *Lingua*, **122**, 181–191.

Marinis, T. (2012). Psycholinguistic techniques in second language acquisition research. *Second Language Research*, **19**, 144–161.

Martín-Loeches, M., Muñoz, F., Casado, P., Melcón, A. & Fernández-Frías, C. (2005). Are the anterior negativities to grammatical violations indexing working memory? *Psychophysiology*, **42**, 508–519.

Matzke, M., Mai, H., Nager, W., Rüsseler, J. & Münte, T. (2002). The cost of freedom: An ERP-study of non-canonical sentences. *Clinical Neurophysiology*, **113**, 844–852.

Meltzer, J.A. & Braun, A.R. (2013). P600-like positivity and Left Anterior Negativityresponses are elicited by semantic reversibility in nonanomalous sentences. *Journal of Neurolinguistics*, **26**, 129–148.

Meyer, M., Friederici, A.D. & von Cramon, D. (2000). Neurocognition of auditory sentence comprehension: event related fMRI reveals sensitivity to syntactic violations and task demands. *Cognitive Brain Research*, **9**, 19–33.

Mitchell, C., Don (1994). Sentence parsing. In M. Gernsbacher, ed., *Handbook of Psy-*

cholinguistics, Academic Press.
Molinaro, N., Barber, H. & Carreiras, M. (2011). Grammatical agreement processing in reading: ERP findings and future directions. *Cortex*, **47**, 908–930.
Molinaro, N., Barber, H., Caffarra, S. & Carreiras, M. (2014). On the left anterior negativity (LAN): The case of morphosyntactic agreement. *Cortex*.
Mueller, J., Hahne, A., Fuji, Y. & Friederici, A.D. (2005). Native and nonnative speakers' processing of a miniature version of Japanese as revealed by ERPs. *Journal of Cognitive Neuroscience*, **17**, 1229–1244.
Mueller, J., Hirotani, M. & Friederici, A.D. (2007). Erp evidence for different strategies in the processing of case markers in native speakers and non-native learners. *BMC Neuroscience*, **8**.
Munarriz, A., Ezeizabarrena, M. & Gutiérrez-Mangado, M.J. (2015). Differential and selective morpho-syntactic impairment in spanish-basque bilingual aphasia. *Bilingualism: Language and Cognition*, **FirstView**, 1–24.
Münte, T., Heinze, H. & Mangun, G. (1993). Dissociation of brain activity related to syntactic and semantic aspects of language. *Journal of Cognitive Neuroscience*, **5**, 335–344.
Neville, H., Nicol, J., Barss, A., Forster, K. & Garrett, M. (1991). Syntactically based sentence processing classes: Evidence from event-related brain potentials. *Journal of Cognitive Science*, **3**, 151–165.
Nieuwland, M.S., Martin, A.E. & Carreiras, M. (2012). Brain regions that process case: evidence from Basque. *Human Brain Mapping*, **33**, 2509–2520.
Ojima, S., Nakata, H. & Kakigi, R. (2005). An ERP study of second language learning after childhood: Effects of proficiency. *Journal of Cognitive Neuroscience*, **17**, 1212–1228.
Osterhout, L. & Holcomb, P. (1992). Event-related brain potentials elicited by syntactic anomaly. *Journal of Memory and Language*, **31**, 785–806.
Phillips, C., Kazanina, N. & Abada, S.H. (2005). ERP effects of the processing of syntactic long-distance dependencies. *Cognitive Brain Research*, **22**, 407–428.
Pickering, M. & Van Gompel, R. (2006). Syntactic parsing. In M. Traxler & M. Gernsbacher, eds., *Handbook of Psycholinguistics*, 455–503, Elsevier, New York.
Polinsky, M., Gallo, C.G., Graff, P. & Kravtchenko, E. (2012). Subject preference and ergativity. *Lingua*, **122**, 267–277.
Tanner, D. (2014). On the left anterior negativity (LAN) in electrophysiological studies of morphosyntactic agreement. *Cortex*.
Tanner, D. & Van Hell, J. (2014). ERPs reveal individual differences in morphosyntactic processing. *Neuropsychologia*, **56**, 289–301.
Traxler, M. & Gernsbacher, M. (2006). *Handbook of Psycholinguistics*. Elsevier, New York.
Trueswell, J. & Kim, A. (1998). How to prune a garden path by nipping it in the bud: Fast priming of verb argument structure. *Journal of Memory and Language*, **39**, 102–123.
Ueno, M. & Kluender, R. (2009). On the processing of Japanese wh-questions: an ERP study. *Brain Research*, **1290**, 63–90.
Ullman, M. (2001). A neurocognitive perspective on language: the declarative / procedural model. *Nature Reviews Neuroscience*, **2**, 717–726.
Ullman, M. (2004). Contributions of memory circuits to language: the declarative/procedural model. *Cognition*, **92**, 231–270.

Wartenburger, I., Heekeren, H.R., Abutalebi, J., Cappa, S.F., Villringer, A. & Perani, D. (2003). Early setting of grammatical processing in the bilingual brain. *Neuron*, **37**, 157–190.

Weber-Fox, C. & Neville, H. (1996). Maturational constraints on functional specializations for language processing: ERP and behavioural evidence in bilingual speakers. *Journal of Cognitive Neuroscience*, **8**, 231–256.

Weckerly, J. & Kutas, M. (1999). An electrophysiological analysis of animacy effects in the processing of object relative sentences. *Psychophysiology*, **36**, 559–570.

Zawiszewski, A., Gutiérrez, E., Fernández, B. & Laka, I. (2011). Language distance and non-native syntactic processing: Evidence from event-related potentials. *Bilingualism: Language and Cognition*, **14**, 400–411.