Processing argument structure complexity in Basque-Spanish bilinguals

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Previous research on argument structure (AS) has shown that verb processing costs scale with the number of arguments and as a result of non-canonical thematic mapping. The Basque language has unique AS: Basque unergatives and transitives select transitive auxiliary and ergative subject case markings, while unaccusatives are syntactically less complex. We studied the contribution of these syntactic factors in seventy-one, simultaneous Basque-Spanish bilinguals, measuring their performance on unergative, unaccusatives, and transitive verbs in a lexical decision and a sentence production task. We observed no differences between verb groups in the lexical decision task. In the production task, Basque unergatives elicited more ungrammatical sentences, while Spanish unaccusatives, in line with previous findings, elicited longer speech onset times. Our results indicate that AS processing can differ across languages, calling for further cross-linguistic investigation.

Keywords: argument structure processing; sentence production; lexical decision; cross-language differences

1. Introduction

1.1. Verbs and argument structure complexity

Verbs play a central part in language, not only describing actions and states but also defining the relationships between sentence constituents. Every verb carries information about argument structure (AS), encoding who performs and who undergoes an event (i.e., who does what to whom). AS information is presumably stored in our mental lexicon, forming part of the lexical-syntactic entry for each verb. It can then be accessed whenever the verb is utilized in production or comprehension.

Verbs can be considered syntactically more or less complex on several dimensions. One important dimension is the number of arguments required: transitive verbs (e.g., *to bring)* require two arguments, a subject and a direct object (the boy $_{SUBJ}$ *brought* an apple $_{DO}$), while intransitive verbs (e.g., *to bark*) require only a subject (the dog $_{SUBJ}$ *barked*). This makes intransitive verbs syntactically less complex. The complexity of AS also depends on how syntactic roles (subject or object) of each argument map onto their thematic roles (agent or theme/patient). In this respect, intransitive verbs can be split into two sub-classes: unergatives (e.g., *to ski*) and unaccusatives (e.g., *to fall*). The subject of unergative verbs is assigned the thematic role of agent (the boy $_{AG}$ *skied*). In contrast, the single argument of unaccusative verbs, although in the syntactic position usually occupied by a subject across many languages, does not denote the individual who actively initiates the action of the verb. It is therefore assigned a theme/patient role, typically associated with an object (the boy $_{PA}$ *fell*). Hence, the pattern of thematic mapping unaccusatives undergo is referred to as non-canonical. Moreover, it has been proposed that even though the argument of unaccusatives is realized on the surface in the position of the subject, it has the syntactic properties of an object (Levin & Rappaport 1995; Perlmutter 1978), and this derivation makes unaccusatives syntactically more complex than their unergative counterparts (Perlmutter 1978; cf. also Burzio, 1986).

In this study we will investigate the impact of different levels of AS complexity on Basque and Spanish verb processing in a group of simultaneous Basque-Spanish bilinguals.

1.2. Processing verbs with different AS complexity

Numerous studies—the majority on Indo-European languages with nominative-accusative case alignment—have addressed the impact of AS complexity on verb and sentence processing. The results suggest that AS becomes more complex if the number of arguments increase or non-canonical thematic mapping is involved. Interestingly, increased processing costs have been observed not only when verbs associated with AS complexity occur within a sentence, but even when they are processed in isolation (for a comprehensive review, see Thompson & Meltzer-Asscher, 2014). Psycholinguistic models propose that these costs are incurred because access to a verb entails access to its syntactic and semantic AS properties, including the number of arguments it takes and the thematic roles it assigns (Bock & Levelt, 1994; Levelt, 1999). AS complexity then affects the ease and speed of lexical access and facilitates or impedes verb use during speech production and comprehension.

With regard to the number of arguments, transitives were shown to be more costly to process than intransitives across monolingual speakers of different languages in a lexical decision (German: Kauschke & Stenneken, 2008), action naming (German: Kauschke & von Frankenberg, 2008; English: Malyutina & Den Ouden, 2015) or AS production task (Italian: Barbieri et al., 2019). Transitives may also be acquired later than intransitives in first-language acquisition (De Bleser & Kauschke, 2003). Studies on individuals with agrammatic aphasia have found that both isolated transitive verbs and sentences with transitive verbs were harder to produce than intransitive verbs for speakers with agrammatism in a number of languages, including English (Cho-Reyes & Thompson, 2012; Kim & Thompson, 2000, 2004; Thompson et al., 1997), German (De Bleser & Kauschke, 2003) or Russian (Dragoy & Bastiaanse, 2010). However, some contradictory evidence has also shown increased processing costs for intransitives

compared to transitives in Dutch speakers with Broca's and anomic aphasia (Jonkers & Bastiaanse, 1997, 1998).

As for thematic mapping, behavioral studies of AS processing that have compared unaccusatives and unergatives report increased processing costs for unaccusatives in a probe recognition task for Spanish speakers (Bever & Sanz, 1997) and in cross-modal lexical priming (Friedmann et al., 2008), action naming (McAllister et al., 2009) or lexical decision task (Meltzer-Asscher et al., 2015) for English speakers. Research has also shown that unaccusatives are acquired later in first-language acquisition (Babyonyshev et al., 2001; Borer & Wexler, 1987) and second-language acquisition (Oshita, 2001). At the neurological level, greater activation for sentences containing unaccusative compared to unergative verbs was shown in the left inferior frontal gyrus and the left middle temporal gyrus (Shetreet et al., 2010; Shetreet & Friedmann, 2012). Finally, speakers with agrammatic aphasia have been reported to have difficulties in production of verbs and sentences with unaccusative verbs in English (Lee & Thompson, 2004; Lee & Thompson 2011; McAllister et al., 2009), Spanish (Martínez-Ferreriro et al., 2014; Sánchez-Alonso et al., 2011), Italian (Luzzatti et al., 2002) and Dutch (Bastiaanse & van Zonneveld, 2005).

1.3. Linguistic and psycholinguistic background for the current study

Languages realize AS in different ways. Basque is an S-O-V ergative-absolutive language with rich inflectional morphology. Both the subject and the direct object agree with the inflected verb in person, number, and case. The direct object of transitive verbs and the subject of unaccusative verbs both have absolutive (zero or Ø) case marking, while the subjects of transitive and unergative verbs both carry ergative case marking

(-k) (see Table 1). Case morphology also usually aligns with thematic roles: absolutive case indicates patients/themes, while ergative case indicates agents. Furthermore, Basque unaccusatives select the intransitive auxiliary *izan* (to be), while unergative and transitive verbs assign the transitive auxiliary *ukan* (to have). Thus, in Basque, unergatives and unaccusatives can be differentiated based on their auxiliary selection and ergative-absolutive case marking (Laka, 1996).

Table 1. Examples of unergative, unaccusative, and transitive verbs and sentences in Basque (ERG = ergative case; AUX = auxiliary; ABS = absolutive case; Ø = zero case marking).

verb type	**examples in Basque**
unergative	Bera-k ERG eskiatu du. AUX She/he skied has. *She/he has skied.*
unaccusative	Bera Ø ABS erori da. AUX She/he fallen is. *She/he has fallen.*
transitive	Bera-k ERG ogi-a Ø ABS jan du. AUX She the bread eaten has. *She/he has eaten the bread.*

The literature on AS processing in Basque is scarce. A recent EEG study by Martinez de la Hidalga, Zawiszewski and Laka (2019) compared processing of unergative and unaccusative sentences that were either grammatical or ungrammatical (due to number or case violations). In the grammatical condition, they found increased processing costs for unergative compared to unaccusative sentences. This goes against most of the evidence from other languages and it suggests that unergatives may be more costly to process than unaccusatives in Basque.

Spanish is a Romance language with nominative-accusative case alignment and less complex agreement patterns than Basque. The subject agrees with the inflected verb and auxiliary in number and person but not case. Verbs select the auxiliary *haber* (to have) for compound tenses irrespective of their verb class (see Table 2), while the auxiliary *ser* (to be) is used in passives. Therefore, in Spanish, the intransitive verb subclasses, the unergatives and unaccusatives, cannot be classified on the basis of case assignment or auxiliary selection. Instead, other syntactic and semantic criteria have to be used to determine the subtype of an intransitive verb.

Table 2. Examples of unergative, unaccusative and transitive verbs and sentences in Spanish (NOM = nominative; AUX = auxiliary; PPC = pretérito perfecto compuesto).

verb type	**examples in Spanish**			
unergative	Ella NOM	ha AUX	esqui-ado PPC.	
	She	has	skied.	
	She has skied.			
unaccusative	Ella NOM	ha AUX	tropez-ado PPC.	
	She	has	stumbled.	
	She has stumbled.			
transitive	Ella NOM	ha AUX	com-ido PPC	el pan.
	She	has	eaten	the bread.
	She has eaten the bread.			

Experimental evidence suggests that AS processing in Spanish resembles that of other languages studied to date. In their pioneering psycholinguistic study, Bever and Sanz (1997) asked Spanish participants to find a probe word in a written sequence. Participants took longer to recognize the probe in sequences with unaccusative compared to unergative constructions. Previous studies in Spanish agrammatic aphasia also reported unaccusative verbs and sentences to be harder to produce and comprehend compared to unergatives (Martínez-Ferreriro et al., 2014). Furthermore, unaccusative

sentences were found to be more difficult to produce compared to their transitive counterparts for verbs with alternating transitivity (Sánchez-Alonso et al., 2011). These patterns are consistent with that found in other studied languages and support the hypothesis that verbs with non-canonical thematic mapping incur increased costs.

No study has yet addressed how AS is processed by bilinguals whose two languages use different AS. Basque-Spanish bilinguals are an especially interesting population in this regard; Spanish verbs share the syntactic properties and AS of Indo-European languages (e.g., English), while Basque exhibits different morpho-syntactic alignment. These differences may lead bilinguals to apply different processing strategies to Basque and Spanish verbs. Studying distinct processing strategies across the two languages could bring more cross-linguistic evidence to inform theories on AS processing.

1.4. Research questions, hypotheses and predictions

The current study sets out to investigate AS processing in simultaneous Basque-Spanish bilinguals. We seek to identify additional factors—beyond number of arguments and non-canonical thematic mapping—that add complexity and therefore could increase processing costs for verbs in Basque. Specifically, we want to look into potential contributions from auxiliary selection and ergative subject inflection in Basque. We will also examine how the number of arguments and non-canonical thematic mapping affect processing costs for verbs in Spanish within this unique bilingual population. To tackle these questions, we recruited a group of simultaneous Basque-Spanish bilinguals and employed a lexical decision and a sentence production task to tap into verb use in both comprehension and production modalities, using a within-subject design. The major strength of this design is that it allows us to study two languages with different

properties in individuals who are fully proficient speakers of both languages, preventing certain individual differences from affecting the results, as would happen in the between-subject design. Moreover, since all the Basque speakers also speak Spanish at some level, it would not be viable to use a between-subject design and compare Basque and Spanish monolinguals. Basque-Spanish bilinguals are prototypical representatives of the current Basque speaking population. Hence, these bilinguals are also an ideal target population to address the questions of our study, as they allow us to investigate cross-language differences in AS processing in these two languages.

We hypothesized that Basque unaccusatives, despite their non-canonical thematic mappings, may be less complex than unergatives and transitives because they i) assign absolutive case to their argument, as demonstrated by zero case marking, and ii) select an intransitive auxiliary due to their intransitive AS.

In contrast, Basque unergatives with canonical thematic mapping and intransitive AS, could be considered more complex than unacusatives because they: i) assign ergative case marking to their argument and/or ii) select a transitive auxiliary which 'mismatches' their otherwise intransitive AS. Similarly, Basque transitives could also be considered more complex than unaccusatives because they i) assign ergative case marking to their argument and ii) have transitive AS motivating transitive auxiliary selection. Our hypothesis is driven by the assumption that the ergative case that the unergatives and transitives assign to their subject, as well as the transitive auxiliaries they select, pose an additional processing cost that can outcompete the processing cost of unaccusatives, whose case assignment is morphologically null in Basque (although they may be still somewhat costly due to non-canonical thematic mapping). In other words, the assignment of the ergative case and its combination with the transitive auxiliary are hypothesized to increase the processing cost for unergatives and transitives

in Basque due to the additional morphological realization. This hypothesis is also consistent with the results of Martinez de la Hidalga et al. (2019), discussed earlier.

Hence, we predicted that Basque unergatives and transitives would be more costly to process than unaccusatives (i.e., unergatives and transitives > unaccusatives) due to the ergative case marking of their subject, transitive auxiliary assignment, or their combination. We further expected these higher processing costs would manifest as slower reaction times (RTs) and speech onset times (SOTs) and higher error rates for unergatives and transitives. In the Basque production task, a higher proportion of omissions or substitutions of ergative morphology compared to other error types would be expected.

In Spanish, we expected to replicate the hierarchy found by previous studies of other Indo-European languages (i.e., unaccusatives and/or transitives > unergatives). Therefore, Spanish unaccusatives and/or transitives were expected to give rise to slower RTs and SOTs and higher error rates than unergatives (see Table 3).

Although we set out to test our predictions in a bilingual population, these predictions are not dependent on the bilingual status of our participants and would stand also for monolingual speakers of Spanish and Basque (if those existed). Furthermore, assuming less proficient speakers of Basque or Spanish were to be recruited than is the case in this study, we would expect the same patterns across the verb groups in the two languages as predicted for the proficient speakers, though perhaps with possible higher error rates and slower reaction times overall, but without affecting any specific verb group in question.

Table 3. A summary of the factors that we hypothesized could influence verb processing costs (Spanish: number of arguments and/or canonicity of thematic mapping; Basque: case assignment and/or auxiliary selection) and predicted hierarchies for AS complexity and processing costs.

	factors	**unergatives**	**unaccusatives**	**transitives**	**predicted hierarchy**
Spanish	number of arguments	1	1	2	unergatives, unaccusatives < transitives
	canonicity of thematic mapping	canonical	non-canonical	canonical	unergatives, transitives < unaccusatives
Basque	case assigned to the subject/ auxiliary selection	ergative/ transitive	absolutive/ intransitive	ergative/ transitive	unaccusatives < unergatives, transitives

Initially, we planned to run statistical comparisons on the selected verb groups separately for each language, due to differences in the psycholinguistic variables of the stimuli sets for the two languages (e.g., word frequencies drawn from different corpora of different sizes) with the reasoning that even without direct statistical comparison, we could draw conclusions about processing costs for Basque compared to Spanish verbs. However, in the end we also decided to conduct and include an additional interaction analysis between verb type and language so as to better demonstrate the cross-linguistic processing differences.

2. Methods

2.1. Participants

Seventy-one simultaneous Basque-Spanish bilingual speakers (19 males) participated in the experiment, ranging in age from 18 to 45 with a mean age of 28 years (SD = 7.08). They were all right-handed, and highly proficient speakers of both languages with a

mean age of acquisition 1.28 (SD = 2.22) in Spanish and 0.74 (SD = 1 .27) in Basque; there was no statistical difference between the two languages in age of acquisition (t = 1.58, p = .11). The majority of participants acquired Basque, Spanish or both of their languages in family setting and received their formal education in Basque. Participants were selected based on the following score ranges from various proficiency measures: score 70 - 100% (scale: 0-100%) in LexTale (Lemhöfer & Broersma, 2012), score 50 - 65 (scale: 0-65) in BEST (de Bruin et al., 2017), and score 4 - 5 (scale: 1-5) in language interviews in both Spanish and Basque. Additionally, participants' grammatical proficiency was tested at the beginning of the experiment via a grammar test designed for the purpose of this study (see *2.3. Procedure*). Our final sample of participants, although highly proficient in both languages, was overall more proficient in Spanish than Basque (see Table 4).

Participants gave written informed consent and received modest monetary compensation for their participation. The study was approved by the BCBL Ethics Review Board and complied with the requirements of the Helsinki Declaration.

Table 4. Means, standard deviations and range of proficiency scores for participants in each language and between-language statistical comparisons (paired two sample *t*-tests) for each of the proficiency measures.

	Basque			**Spanish**			***t*-test**	
test (min-max)	**mean**	**SD**	**range**	**mean**	**SD**	**range**	***t*-value**	***p*-value**
LexTale (0-100%)	91.33	6.45	74 – 100	93.37	5.48	78 – 100	2.18	.03
Best (0-65)	61.13	3.36	54 – 65	64.52	1.16	58 – 65	7.62	< .01
interview (0-5)	4.69	0.47	4 – 5	4.93	0.26	4 – 5	3.53	< .01
grammar test (0-20)	15.27	3.12	6 – 20	15.48	2.35	9 – 20	0.46	.65

2.2. Stimuli

Spanish and Basque verb sets were selected and separately categorized as unergative, unaccusative, or transitive based on criteria appropriate for characteristics of each language (since each language requires different unaccusative/unergative diagnostic tools). Both sets of verbs were examined by two independent linguists (Spanish by Spanish monolinguals and Basque by Basque-Spanish bilinguals).

The transitive verbs were assessed for their causative alternation and optional vs. obligatory transitivity. The transitive verbs selected for the final stimuli list were predominantly obligatorily transitive with a few optionally transitive items balanced across both languages (i.e., five items in both Spanish and Basque). In Spanish, only the non-alternating transitives were selected for the final stimuli list. In Basque, some items used in the final stimuli list allow causative alternation, but only with the auxiliary *izan (to be)*. Hence, we decided to present all the transitive verbs together with the auxiliary *ukan (to have)* to avoid their unaccusative reading and we added auxiliaries to the rest of stimuli list for both languages to keep the auxiliary use constant across all verbs.

The intransitive verbs were examined for their semantic properties and ordered on a scale from unergative-unaccusative.[i] Following this semantic categorization, syntactic diagnostics appropriate to each language were applied. Since Basque unaccusative verbs typically select the auxiliary *izan (to be)*, while unergatives typically take the auxiliary *ukan* (*to have*) (Laka, 1996), we designed an auxiliary acceptability test to check our initial unergative/unaccusative classification. Twenty-four Basque speakers (9 male) ranging in age from 24 to 35 with a mean age of 28 years (SD = 2.87) with the same language profile as our participants assessed the acceptability of pre-selected verbs presented with each of these auxiliaries in counterbalanced lists, selecting only one verb-auxiliary combination for each item (8 participants per list, not recruited

for the main study). A verb was only selected for the final stimulus list if there was a majority preference (more than 50%) for one auxiliary over the other and if this preference also matched the initial semantic categorization. We also compared the acceptability scores of verb-auxiliary pairs selected for our final stimuli list to control for possible differences in processing associated with their acceptability. The single factor ANOVA revealed no difference in acceptability scores ($F = 1.10$, $p = .34$) across the three verb types.

In Spanish, we designed an acceptability rating scale based on 5 syntactic diagnostics (see Table S1, Supplementary materials). Eight native Spanish speakers rated the acceptability of verbs in sentences with these syntactic constructions on a scale from 1 (not natural at all) to 5 (perfectly natural). A verb that received a rating of 4 or more on any given sentence, was considered to have passed the given syntactic test. Each verb was assigned one point for each test passed. If the verb passed at least 4 out of 5 syntactic tests, it was categorized as unergative or unaccusative for that participant. Finally, we averaged ratings across all participants and used these mean scores together with the initial semantic categorization to classify verbs as unergative or unaccusative. Unlike in the Basque acceptability rating, the Spanish phrases were not split into separate lists and all participants could see all the items throughout the rating. Hence, an equal number of 8 responses for every rated Spanish and for every rated Basque phrase was collected to obtain the final rating score for each language. The reason why we employed distinct diagnostic tools for Basque and Spanish verbs stems from the typological difference between the two languages. While Basque unergatives and unaccusatives can be differentiated based on their ergative-absolutive case marking (Laka, 1996), these syntactic features are not present in Spanish and other syntactic and semantic criteria have to be used to determine the intransitive verbs' subtypes.

The final list of stimuli consisted of 19 verbs and auxiliaries per verb group and language (see Table S2, Supplementary materials). All verbs were presented in the 3rd person singular and present perfect tense, which corresponds to the *pretérito perfecto compuesto* in Spanish (e.g., *ha andado* / *has walked*) and to the infinitive plus present-tense auxiliary verb form in Basque (e.g., *erori da* / *has fallen*). The three verb categories within each language were balanced in terms of logarithmic frequency, length, orthographic neighborhood, and cognate status as measured by Levenshtein distance (see Table S3, Supplementary materials). Apart from the target stimuli, we also selected 19 filler verbs for each language. These were similar to the group of target verbs in terms of verb AS (i.e., fillers included transitives, unergatives and unaccusatives), but differed in frequency (i.e., they had higher or lower frequency than the target verbs).

In the lexical decision task, the target and filler verbs were paired with pseudo-verbs generated by *Wuggy* (Keuleers & Brysbaert, 2010). Each selected pseudo-verb had one syllable shared with the corresponding real verb. Each pseudo-verb was also paired with existing auxiliary to form pseudo-verb phrases (e.g., Spanish verb: *ha hablado* / pseudo-verb: *ha neprado;* Basque verb: *erori da /* pseudo-verb: *asori da*). We decided to add these auxiliaries to our verbs to disambiguate items in Basque, where auxiliaries can determine verb interpretation; the Spanish verbs were also paired with auxiliaries to match the Basque stimuli set. The final list of stimuli in the lexical decision task consisted of 76 real verbs (57 targets and 19 fillers) and 76 pseudo-verbs; in the sentence production task we used only the target verbs and fillers.

2.3. Procedure

The experiment was divided into two language blocks. Half of the participants began with the Spanish, while and the other half began with the Basque block. Participants were seated in a behavioral cabin in front of a keyboard and computer screen. Before each task, participants received instructions in the language corresponding to that block, both from the experimenter and in written form on the computer screen. All the tasks were coded and run using *Psychopy*, version 1.83.04 (Peirce, 2007). After hearing the initial instructions, participants were asked to complete a short grammar test to control for grammatical proficiency in the language corresponding to the given language block. This test consisted of 20 multiple choice questions mainly focused on agreement, auxiliary selection, and other types of grammatical features related to AS or general grammar use (see Appendix S4, Supplementary materials). There was no time limit and participants could take as long as needed to complete the test.

The block continued with a lexical decision task in the same language (either Spanish or Basque). Participants were instructed to indicate if the string presented on the screen was a real verb phrase in the given language by pressing the corresponding keyboard key. After two written examples and 6 practice trials, a fixation cross appeared on screen for 1000 ms and the task started. This same cross also appeared between each trial. The target verb phrases (the verb and auxiliary), fillers, and pseudo-verb phrases were presented in random order on a grey background in a white Helvetica font, size 30. There was no time limit for responses but participants were instructed to respond as fast and as accurately as possible.

Finally, a sentence production task was administered. Participants were provided with a set of headphones with a microphone and instructed to orally produce simple sentences from the preamble displayed on screen (e.g., *ha caminado / has walked*;

flotatu du / has floated) in the 3rd person, singular, present perfect tense (e.g., *el chico ha caminado mucho* / *the boy has walked a lot*; *kortxoak flotatu du* / *the cork has floated*). Before the main experiment, participants saw two examples and completed 5 practice trials. If the participant demonstrated that they had understood the task, the experiment started: a fixation cross appeared on screen for 2000 ms; followed by a verb phrase that appeared for 3000 ms; then participants were asked to orally produce a sentence within 5000 ms (including stimulus and fixation cross displays). Then the next stimuli appeared, and the audio recording was reset. Time pressure was introduced to increase task demands and make lexical access and sentence production more automatic, less controlled, processes.

Upon completing all the tasks described above, the same procedure continued in the other language block. The whole experiment, including instructions, grammar tests, and both language blocks lasted approximately 30 minutes.

2.4. Data analysis

In the lexical decision task, we collected both error rates and RTs for each trial and language. The final analysis included all the target items (except one Spanish verb, which was accidentally misspelled in the final stimuli list) from all participants (n = 71). For the RT analysis, we first excluded trials with incorrect responses (8.27 % in Basque; 2.38 % in Spanish), then the outlier RTs lower than 0.2 s, which is the minimum needed to encode the visual stimulus, and higher than 4 s, reflecting lapses of attention rather than the cognitive processes in question (Baayen & Milin, 2010), were discarded (0.43% in Basque; 0.05% in Spanish). The responses were analyzed by fitting generalized (for error rates) and linear mixed-effect models (for log-transformed RTs) with verb type as a predictor (default contrast-coded) using the lme4 package (Bates,

Maechler & Bolker, 2012) in R (R Core Team, 2020), following the linear mixed-effects approach described by Baayen, Davidson and Bates (2008). Likelihood ratio tests were used to compare models with increasingly complex fixed- and random-effect structures (Barr et al., 2013). When the models did not converge, the random-effect structure was progressively simplified by removing random slopes (by-subject and by-item, respectively) until convergence was reached. For RTs, linear model assumptions were checked; non-homoscedasticity of the residuals was corrected by log-transforming the RTs. Bonferroni-corrected contrasts among levels of the verb type were carried out using the emmeans package (Lenth et al., 2018).

In the sentence production task analysis, we used all target verbs (with the exception of the single misspelled Spanish verb) and all the participants (with the exception of one participant´s recordings in the Spanish block, which were lost due to technical difficulties). The recorded utterances were transcribed and assessed by two Basque (both Basque-Spanish bilinguals) and two Spanish (one Spanish monolingual and one Basque-Spanish bilingual) linguists for grammaticality and this assessment was used to measure error rates. For the final error rate analysis, we excluded all trials with missing, incomplete, or self-corrected utterances as well as those trials where the verb was misread by the participant or used with a different auxiliary than indicated. We did not code the substitution of different auxiliaries in the production task as grammatical errors, because there is high variability among Basque verbs and their auxiliary use as we have seen in the auxiliary acceptability test (see *2.2. Stimuli*). Therefore, we decided to categorize the auxiliary substitution as failure to follow the task instructions rather than a grammatical error (see Figures S1a and S1b for overview of grammatical errors). Although we instructed participants to produce subject and object (when necessary) with target verbs, some utterances produced by participants had unexpressed subjects

(e.g., *Ha salido de la casa* / *"Has left the house"*; *Asko bidaiatu du*. / *"Has traveled a lot"*), which is frequent in both Spanish and Basque. Therefore, we did not treat unexpressed subjects as grammatical errors. However, we controlled the occurrence of unexpressed subjects in the utterances across conditions to exclude the possibility that omitting the subject would significantly impact the SOT results (see Tables S5a and S5b, Supplementary materials). In Spanish, participants also used post-verbal subject structures (e.g., *Ha expirado la fecha* / *Has expired the date*"), which are grammatically acceptable and hence such sentences were treated as grammatically correct. Finally, although Basque speakers show certain variability in their production of ergative subject inflection (-*k*) reflected as inconsistencies in its use during Basque language acquisition (Ezeizabarrena, 2011; Rodríguez-Ordóñez, 2015), they also show high consistency in perceiving its omission as a grammatical error (Rodríguez-Ordóñez, 2015; Zawiszewski et al., 2011; Zawiszewski & Laka, 2020). Hence, we decided to operationalize this omission as an error for the purpose of our study. Since ergative encoding in a verb argument is manifested via case or agreement patterns, we reasoned that the agreement errors, including omissions, are directly informing us about the processing difficulty of the verbs' AS. In other words, if the processing demands of a verb with ergative case assignment are too high, the agreement errors are more likely to be committed.

Only the trials included in the error rate analysis were also included for the SOT analysis. We extracted SOTs from the audio recordings of participants' responses using *Chronset* (Roux et al., 2016) and manually checked all the generated SOTs. In this analysis, we excluded the SOTs of sentences that were judged ungrammatical (5.9% in Basque. 0.19 % in Spanish). We fitted generalized (for error rates) and linear mixed-effect models (for log- transformed SOTs) with verb type as a predictor (default contrast-coded), using the same model selection and data trimming procedures as used

for the lexical decision task. One exception was the Spanish production task, where we ran into a case of complete separation, or perfect predictability, given by 0 errors in one of the levels of our verb type predictor (i.e., unergative verbs). To handle this case, we adopted the *bglmer* function from the *blme* package (Dorie, 2015), which allowed us to fit the general linear mixed model to a dataset where one of the conditions was a perfect predictor of the outcome. You can access all the data analysis scripts at: https://osf.io/t9pz5/?view_only=11929d2bc5784298b746c5038c02bfbe

3. Results

3.1. Lexical decision task

In the lexical decision task, error rates reached 2.38% in Spanish (unergative: 3.93%, unaccusative: 1.96%, transitive: 1.26%) and 8.77% in Basque (unergative: 8.38%, unaccusative: 7.19%, transitive: 9.27%) (see Figure 1). The best fitting and maximally converging model included the fixed effect of verb type and by-item and by-subject random intercepts. Verb type did not prove to be a significant predictor of error rates in either language (for complete results and model details, see Table 5).

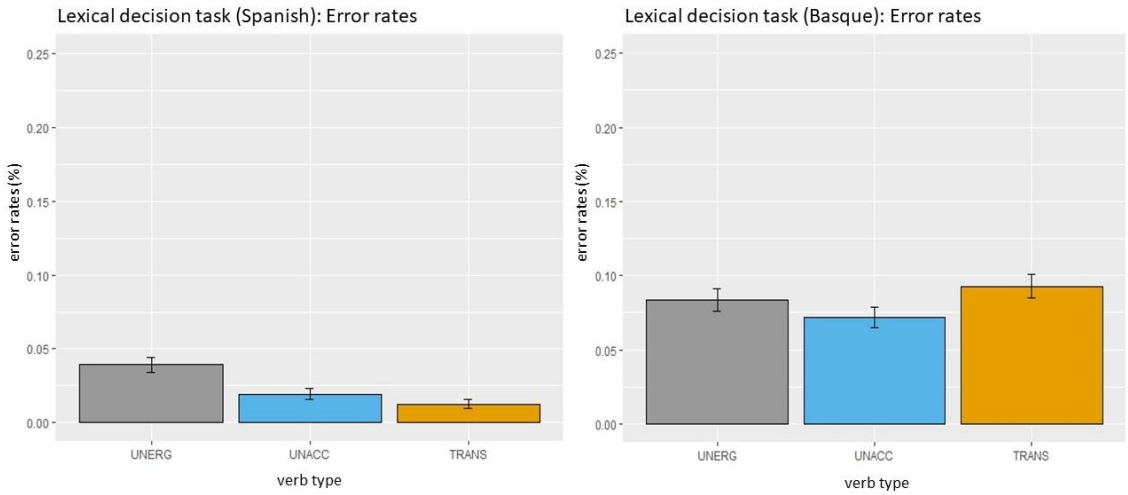

Figure 1. Percentage of errors in Spanish and Basque lexical decision tasks for the three verb types (unergatives, unaccusatives, transitives); error bars indicate the standard error of the mean.

Additional Bayesian inferential methods were used to assess whether the null results for error rates obtained in both languages indeed represented evidence of no differences between the levels of the verb type predictor, i.e., provided evidence for the null hypothesis. After fitting a model with *stan_glmer* function from the rstanarm package (Gabry et al., 2020) using default priors, Bayes factors (BFs) were computed with the *bf_pointnull* function from the bayestestR package (Makowski et al., 2019) to assess the likelihood of effect presence against its absence. Based on Jeffreys (1961) rule, BFs revealed moderate evidence in favor of the null hypothesis for the analysis of error rates in Spanish (transitive vs. unaccusative: BF = 0.15; transitive vs. unergative: BF = 0.24; unergative vs. unaccusative: BF = 0.27). Similarly, in Basque we found moderate evidence for the null hypothesis for the analysis of error rates (transitive vs. unaccusative: BF = 0.12; transitive vs. unergative: BF = 0.14; unergative vs. unaccusative: BF = 0.12).

The mean RTs for the lexical decision task were 0.73 s in Spanish (unergative: 0.74 s, unaccusative: 0.73 s, transitive: 0.72 s) and 0.92 s in Basque (unergative: 0.92 s,

unaccusative: 0.93 s, transitive: 0.91 s) (see Figure 2). The LMEMs showed no significant difference in RTs for different verb types in either language (see Table 5).

Bayes Factors revealed strong evidence in favor of the null hypothesis both in Spanish (transitive vs. unaccusative: BF = 0.020; transitive vs. unergative: BF = 0.020; unergative vs. unaccusative: BF = 0.033) and Basque RT analysis (transitive vs. unaccusative: BF = 0.024; transitive vs. unergative: BF = 0.024; unergative vs. unaccusative: BF = 0.026).

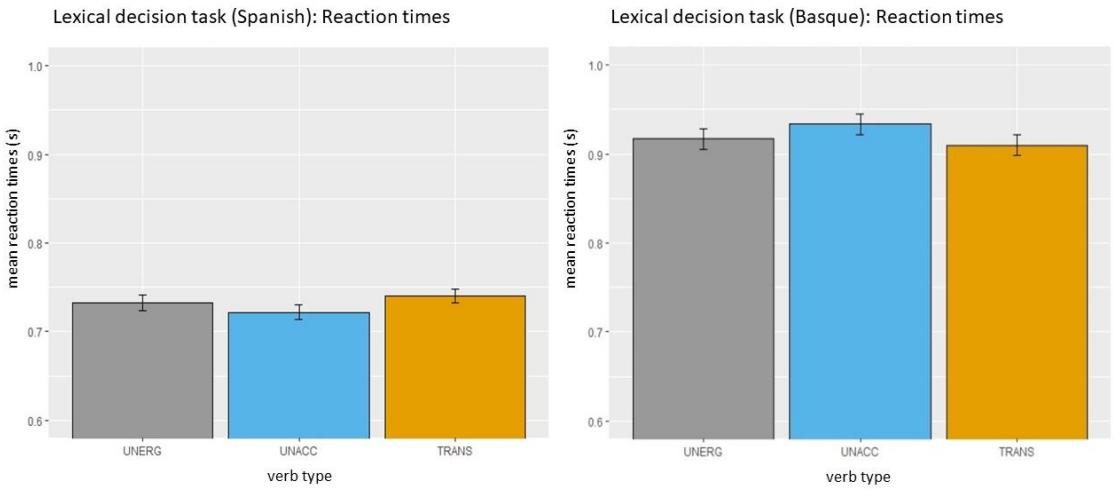

Figure 2. Mean RTs (s) in Spanish and Basque lexical decision tasks for the three verb types (unergatives, unaccusatives, transitives); error bars indicate the standard error of the mean.

Table 5. Fitted linear and generalized mixed-effect models for lexical decision tasks in each language; *p*-values are Bonferroni corrected for multiple comparisons (note that Bonferroni correction adjusts *p*-values, and this adjustment can result in values > 1, in which case the *emmeans* function rounds the values down to 1).

Lexical decision task (Spanish)

Error rates				
Model:	**glmer** (errors ~ verb type + (1 | subject) + (1 | item))			
Contrast	**estimate**	**SE**	***z*-ratio**	***p*-value**
transitive : unaccusative	-0.464	0.592	-0.784	.7131
transitive : unergative	-0.902	0.575	-1.569	.2593
unaccusative : unergative	-0.438	0.563	-0.778	.7165

RTs				
Model:	**lmer** (log(RT) ~ verb type + (1|subject) + (1|item))			
Contrast	**estimate**	**SE**	***z*-ratio**	***p*-value**
transitive : unaccusative	-0.0132	0.0293	-0.452	1.000
transitive : unergative	-0.0326	0.0289	-1.127	.7928
unaccusative : unergative	-0.0193	0.0293	-0.660	1.000

Lexical decision task (Basque)

Error rates				
Model:	**glmer** (errors ~ verb type + (1|subject) + (1|item))			
Contrast	**estimate**	**SE**	***z*-ratio**	***p*-value**
transitive : unaccusative	-0.148	0.564	-0.262	1.0000
transitive : unergative	-0.329	0.563	-0.586	1.0000
unaccusative : unergative	-0.182	0.554	-0.327	1.0000

RTs				
Model:	**lmer** (log(RT) ~ verb type + (1|subject) + (1|item))			
Contrast	**estimate**	**SE**	***z*-ratio**	***p*-value**
transitive : unaccusative	-0.0108	0.0469	-0.229	1.0000
transitive : unergative	0.0023	0.0469	0.049	1.0000
unaccusative : unergative	0.0131	0.0469	0.278	1.0000

3.2. Sentence production task

As for error rates in the sentence production task, participants overall produced 0.19% ungrammatical sentences in Spanish (unergative: 0%, unaccusative: 0.26%, transitive: 0.33%) and 5.90% in Basque (unergative: 10%, unaccusative: 3.41%, transitive: 4.34%) (see Figure 3).

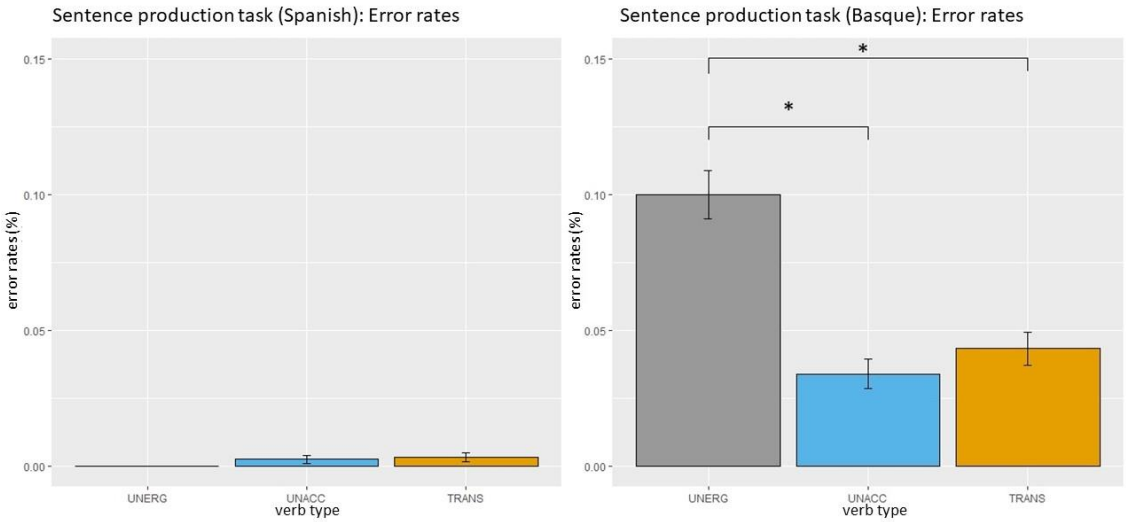

Figure 3. Error rates (%) for each verb group (unergatives, unaccusatives, transitives) in the sentence production tasks in both Spanish and Basque; the asterisks denote significant differences between the two verb types.

In Spanish, GLMEM analysis showed no significant differences among the three verb types in terms of error rates (see Table 6). BFs partially confirmed the results of the frequentist analysis, revealing moderate evidence in favor of the null hypothesis for the transitive vs. unaccusative comparison (BF = 0.019) and weak evidence for the null hypothesis in the unaccusative vs. unergative comparison (BF = 0.7). In contrast, BFs pointed to weak evidence favoring the alternative over the null hypothesis for the transitive vs. unergative comparison (BF = 1.72). We surmise that the contradictory results of the mixed model and Bayesian analysis are due to the overall very low number of errors produced (e.g., in total, participants produced 0 errors in the unergative, 4 errors in the transitive, and 3 errors in the unaccusative condition).

In Basque, GLMEMs revealed that while the comparison between unaccusatives and transitives was not significant (see Table 6) with BFs showing strong evidence for the null hypothesis (BF = 0.081), participants did produce significantly more ungrammatical sentences after unergatives than after transitive and unaccusative verbs.

As for the SOTs in the sentence production task, the overall mean SOT in Spanish was 1.55 s (unergative: 1.50 s; unaccusative: 1.59 s; transitive: 1.55 s) and 1.96 s in Basque (unergative: 1.94 s; unaccusative: 1.99 s; transitive: 1.96) (see Figure 4). In Spanish, LMEMs showed no significant difference in SOTs for production of transitives vs. unaccusatives and transitives vs. unergatives, and the BFs strongly confirmed the null hypothesis in comparisons between transitives and both unaccusatives and unergatives (BF = 0.02 and BF = 0.04, respectively). However, SOTs were significantly faster for unergative than unaccusative sentences (see Table 6).

In Basque, LMEMs revealed that verb type was not a significant predictor of SOTs. The BFs confirmed that the data provided strong evidence for the null hypothesis (transitive vs. unaccusative: BF = 0.017; transitive vs unergative: BF = 0.019; and unaccusative vs. unergative: BF = 0.022).

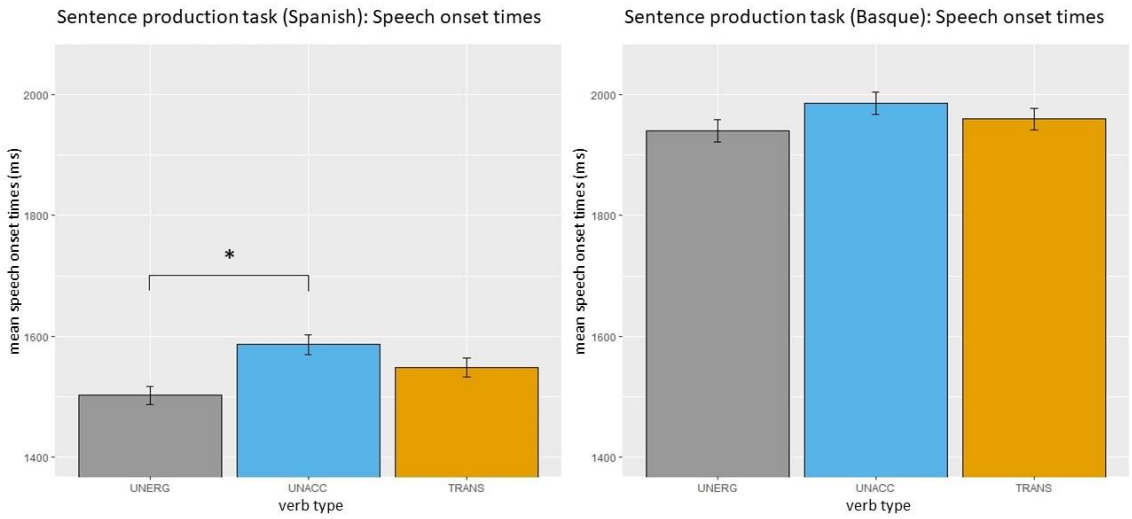

Figure 4. Mean SOTs (ms) for each verb group (unergatives, unaccusatives, transitives) in the sentence production task in both Spanish and Basque; the asterisks denote significant differences between the two verb types.

Table 6. Fitted linear mixed-effect models and generalized mixed-effect models for the sentence production tasks in Spanish and Basque; *p*-values are Bonferroni corrected for multiple comparisons (note that Bonferroni correction adjusts *p*-values, and this adjustment can result in values > 1, in which case the *emmeans* function rounds the values down to 1).

Sentence production task (Spanish)

Error rates				
Model:	**bglmer** (errors ~ verb type + (1|subject) + (1|item))			
Contrast	**estimate**	**SE**	***z*-ratio**	***p*-value**
transitive : unaccusative	0.441	1.05	0.420	1.0000
transitive : unergative	1.962	1.56	1.261	.6223
unaccusative : unergative	1.521	1.74	0.875	1.0000
Speech onset times				
Model:	**lmer** (log(SOT) ~ verb type + (1|subject) + (1|item))			
Contrast	**estimate**	**SE**	***z*-ratio**	***p*-value**
transitive : unaccusative	-0.0252	0.0227	-1.112	.7991
transitive : unergative	-0.0350	0.0223	-1.566	.3522
unaccusative : unergative	-0.0601	0.0226	-2.660	.0234*

Sentence production task (Basque)

Error rates				
Model:	**glmer** (errors ~ verb type + (1 + verb type|subject) + (1|item))			
Contrast	**estimate**	**SE**	***z*-ratio**	***p*-value**
transitive : unaccusative	0.643	0.587	1.095	.8200
transitive : unergative	1.721	0.544	3.165	.0047*
unaccusative: unergative	1.078	0.383	2.814	.0147*
Speech onset times				
Model:	**lmer** (log(SOT) ~ verb type + (1+ verb type|subject) + (1|item))			
Contrast	**estimate**	**SE**	***z*-ratio**	***p*-value**
transitive : unaccusative	-17.2	53.9	-0.319	1.0000
transitive : unergative	-17.3	52.9	-0.328	1.0000
unaccusative : unergative	-34.5	53.6	-0.645	1.0000

4. Discussion

The present study compared the processing costs of three verb groups (unergatives, unaccusatives, and transitives) that vary in terms of AS complexity in simultaneous Basque-Spanish bilinguals, whose two languages have distinct AS realization and morpho-syntactic alignment. Our hypothesis predicted the following patterns for the two languages: In Basque, unaccusatives should be easier to process—due to their intransitive auxiliary selection and/or absolutive case marking—than unergatives and transitives, which both have transitive auxiliaries and assign ergative case (i.e., unaccusatives < unergatives, transitives). This pattern of results was not expected for Spanish, where the hierarchy should follow the pattern observed in other languages with nominative-accusative case alignment (i.e., unergatives < unaccusatives and/or transitives). We used a lexical decision task to test verb processing and a sentence production task to test AS production.

The results from the lexical decision task showed no effect of verb type in either language, going against our initial hypothesis. However, the results in the Basque sentence production task partially supported our hypothesis, as not only unaccusatives but also transitives were less likely to elicit ungrammatical sentences than unergatives; nevertheless, no effect of verb type was found in the Basque SOT analysis. In the error rate analysis of the Spanish sentence production task, we found no effect of verb type on error rates. However, the results of the SOT analysis showed increased SOTs for unaccusatives as compared to unergatives in Spanish. This result aligns with previous studies on other languages with nominative-accusative case alignment. Below, we discuss these results, their implications and possible limitations of this study.

4.1. The lexical decision vs. the sentence production task: explaining divergent outcomes

The null results obtained in the lexical decision task for both languages go along with previous studies on agrammatic aphasia, where varying AS complexity has produced effects in production tasks, such as verb naming, narrative elicitation, or picture-elicited sentence production, but not in comprehension tasks such as grammatical judgement, verb comprehension or word-picture matching (Kim & Thompson, 2000; Lee & Thompson, 2004; Thompson, 2003). In an attempt to explain this discrepancy between the two modalities, Kim and Thompson (2000) argued that during comprehension related tasks, where stimuli are externally generated, access to a verb's lexical-syntactic properties is automatic and non-conscious and the processing of externally provided information is implicit, resulting in at-ceiling performance. By contrast, production tasks require conscious recall of AS information as participants self-generate a verb and its basic syntactic structure (e.g., number of arguments, thematic mapping and syntactic positions) for sentence production. When the AS becomes more complex, more time is required for processing, and the chance of failing to access information increases. Thus, in the attempt to recall and produce verbs and sentences with more complex AS in action naming and sentence elicitation tasks, both language-impaired and non-impaired speakers face increased difficulties (e.g., elicited sentence production: Lee & Thompson, 2011; action naming: De Bleser & Kauschke, 2003, Kauschke & von Frankenberg, 2008; picture description with priming probes: Momma et al., 2018). In line with this reasoning, the discrepancy between the results we obtained in the lexical decision and sentence production tasks might stem from inherent differences between the production and comprehension modalities, since the computational demands and processing routines for language production are presumably higher. At

first glance, this explanation appears to be inconsistent with studies reporting AS complexity effects in comprehension tasks (e.g., probe recognition: Bever & Sanz, 1997; lexical decision: Kauschke & Stenneken, 2008; Meltzer-Asscher et al., 2015). However, if we take a closer look at these studies, Bever and Sanz (1997) tested a small sample size on only a few experimental items (8 per verb group) and reported a relatively small verb type effect. Kauschke and Stenneken (2008) found only numeric, statistically non-significant differences between intransitive and transitive verbs. Meltzer-Asscher et al. (2015) found significant differences for non-alternating unaccusatives (e.g., to fall: *he fell*) compared to alternating unaccusatives (e.g., to break: *he broke the vase* / *the vase broke*), transitives, and unergatives. However, in this study, the response for the lexical decision task was time-limited, while in our study the participants had unlimited time to press the key, which could have created more variance in our data, lowering the chance of finding significant effects.

Setting aside these general differences between the comprehension and production modalities, there were also some task-specific differences in our study. In the lexical decision task, speakers were asked to determine if a letter string was or was not an existing verb phrase. Traditional approaches to AS (e.g., Jackendoff 1972; Levin & Rappaport, 1986; among others) assume that recognizing an existing verb phrase requires access to its unique lexical representation, including AS information. However, it is also possible that lexical decision tasks used to test comprehension are relatively automatic and effortless and can be performed without accessing complete AS information. In contrast, in our sentence production task, participants not only had to read the target verb phrases but also to utter a grammatical sentence using a prescribed tense, number, and person. According to Levelt's model of speech production (Levelt 1989, 1999), generating a grammatically sound sentence in a given syntactic framework

requires full access to a verb's syntactic and thematic information. In addition to lexical-syntactic access, planning and production-specific encoding mechanisms must be in place to ensure that each word takes the correct morpho-phonological form and the words and sounds appear in the required linear sequences. Hence, the production task we employed was likely to be more demanding overall and thus presumably more apt to elicit AS complexity effects.

There is yet another specific difference between the two tasks; in our sentence production task, participants were under considerable time pressure, designed to tax processing. However, we did not set time limits for the lexical decision task, where responses are both fast and automatic. Perhaps, if we have had introduced time pressure or other kind of task demands, bigger differences would have emerged between our verb groups.

Finally, it could also be that the processing differences that did occur in the lexical decision task were simply too hard to detect using behavioral measures. This could either be due to the high automaticity of the task and consequent at-ceiling performances or because of high RT variability among subjects and trials. Indeed, previous studies employing lexical decision tasks have reported transitivity and unaccusativity effects at the neurophysiological level (i.e., increased brain activation for transitive and unaccusative as compared to both intransitive and unergative verb groups), despite failing to find any behavioral effects (e.g., Meltzer-Asscher et al., 2015; Thompson et al., 2007; Thompson et al., 2010).

4.2. The sentence production task: verb type effects on error rates

In the Basque sentence production task, the number of ungrammatical sentences produced with unergative verbs was significantly higher than that generated by

unaccusatives and transitive verbs. This pattern is consistent with the results of Rodríguez-Ordóñez (2015), who measured ergative inflectional morphology errors and found unergatives to be more problematic compared to unaccusatives and transitives in both native and non-native Basque speakers. They explain their findings as a clash that occurs at the semantic-syntactic interface of unergative verbs. We interpret our results from a similar perspective and argue that the source of the observed effect could be the ergative case assignment and auxiliary selection typical of transitive verbs that "mismatches" the intransitive meaning of the unergative verbs in Basque.

According to our initial hypothesis, either auxiliary selection or case assignment could increase processing costs in unergative and transitives verbs in Basque. If transitive auxiliary assignment had been the sole factor responsible for this increase, both unergatives and transitives would be expected to elicit more ungrammatical sentences than unaccusatives. This was not the case in our study where unergatives were more likely to elicit ungrammatical sentences compared to unaccusatives and transitives, which suggests that the presence of a transitive auxiliary does not in itself render sentences more prone to grammatical errors. This goes partially in line with previous results from Italian speakers with aphasia (Luzzatti et al., 2002). Similar to Basque, Italian also assigns distinct auxiliaries for unergatives and transitives, i.e., *avere* (*to have*), compared to unaccusatives, i.e., *essere* (*to be*). In their study, Luzzatti et al. (2002) found increased error rates for unaccusatives compared to unergatives and transitives in the action naming task, indicating that the transitive auxiliary does not contribute to the verbs' processing costs. In contrast to Luzzatti et all., (2002) our results show that unergatives, not unaccusatives, are more likely to elicit grammatical errors. One difference between Italian and Basque is the ergative case marking, and, as we initially hypothesized, ergative case assignment might contribute to processing costs

in Basque unergatives and transitives. However, since both transitive and unergative verbs require ergative case marking and our results show increased error rates only for unergatives, it seems that ergative marking alone does not increase the likelihood of grammatical errors either. All in all, we propose that the increased error rate in unergative verbs might be due to "the apparent mismatch" that arises when ergative case marking and transitive auxiliary typical for transitive sentences occur in an intransitive sentence. The fact that most of the grammatical errors produced in Basque were related to the lack of ergative case marking and these occurred mostly in unergative sentences also supports the view that Basque speakers find unergatives more difficult due to the somewhat confusing use of transitive morphology present in the intransitive sentence (for an overview of the types of grammatical errors produced, see Figures S1a and S1b, Supplementary materials). However, the presented findings are exploratory and our claim remains speculative until further evidence from other languages with ergative-absolutive alignment and from additional experiments, e.g., with less time restrictions and a more natural sentence elicitation, is provided.

One alternative explanation for the unaccusative advantage could be the higher frequency with which unaccusative verbs assign absolutive case to their subjects. Some studies on ergative languages have attributed the advantage found for absolutive structures to their relative frequency. For example, Tollan, Massam and Heller (2019) argue that because the absolutive case appears in more syntactic environments than the ergative case in Niuean, an ergative-absolutive Polynesian language, absolutive structures (in absolutive dependencies in their study) are easier to process. In Basque, both unaccusative subjects and transitive objects are marked with absolutive case, while only the subject (of unergative or transitive verbs) can be marked with ergative case. However, even though the absolutive case appears in wider range of syntactic

environments in Basque, our results do not support the frequency-based account: in our sentence production task, transitives, despite assigning ergative case to their subject, elicited a similarly low number of errors as unaccusatives.

We also tested a hypothesis that Basque-Spanish bilinguals, who are frequently exposed to Spanish, do not have well internalized ergative-absolutive case alignment. This may make them more prone to errors when producing unergative sentences that are intransitive, yet exhibit transitive grammatical features. If this were the case, one would expect exposure to Spanish and proficiency in Basque to predict error rates. We tested this in an additional exploratory analysis where mean exposure to Spanish and grammatical proficiency in Basque (as measured by the grammar test designed for this study) were included in a series of generalized linear mixed-effect models to assess whether their inclusion increased model fit over the simple model used in our main analysis and whether they could explain the patterns of errors produced. The results showed that the inclusion of both Spanish exposure and Basque grammatical proficiency improved model fit, but there was no interaction between these factors and verb type and they did not reduce the effect of verb type (see Table S6a, Supplementary materials). This indicates that both exposure to Spanish and proficiency in Basque modulate error rates but this modulation occurs across the board, without targeting any specific verb type.

We also considered that possible cross-language transfer from Spanish to Basque might have contributed to the increased error rate for specific items (e.g., cognates) in the unergative group. Given that our bilingual participants were more proficient in Spanish, it is possible that Spanish AS influenced the way they semantically (and phonologically) processed similar verbs in Basque. However, upon closer look at the more problematic verbs in the unergative group and error-rates on

cognate vs. non-cognate verbs across verb groups, we concluded that cognate status *per se* was not responsible for the tendency to omit ergative case marking (see Figure S2, Supplementary materials).

In the Spanish sentence production task, we did not observe any effect of verb type on error rates. We attribute this to ceiling performance, and the low number of ungrammatical sentences produced. There are at least two reasons why the task proved easier in Spanish than Basque. Firstly, in Spanish the subject always takes the nominative case, requiring no overt case marking. The types of errors found in Basque—most often related to ergative case marking—simply cannot be committed in Spanish (see Figures S1a and S1b, Supplementary materials). Secondly, although all of our participants were highly proficient speakers of both Spanish and Basque, the bilinguals in our sample were more proficient in Spanish with more overall exposure to Spanish, and thus less likely to produce grammatical errors in this language.

4.3. The sentence production task: verb type affects SOTs in Spanish but not Basque

In the Spanish sentence production task, we observed longer SOTs for unaccusatives than unergatives. These results replicate previous studies showing increased costs for unaccusatives across a variety of tasks and languages. A possible explanation for this pattern is that unaccusative and unergative subjects are assigned different syntactic and thematic roles. As the Unaccusativity Hypothesis (Burzio, 1986; Levin & Rapapport, 1995; Perlmutter 1978; Perlmutter & Postal, 1984) proposed, the argument of unergative verbs is the subject, while the argument of unaccusative verbs is a direct object occupying the subject position as a result of derivation. According to this theoretical approach, the two subclasses of intransitive verbs also differ semantically (i.e., in the way they assign these thematic roles to their single argument). Unergatives

assign their subject an agent role, while the subject of unaccusatives is a patient, giving rise to a non-canonical pattern of thematic assignment (the syntactic position of the subject is canonically occupied by an agent, not a patient). Our results support this view, indicating that the theoretical distinction between the two verb groups could be reflected in processing costs.

A question is why unaccusatives elicit longer SOTs, i.e., latencies that can be observed even before an utterance is produced? Previous studies suggest that AS information can be utilized at the level of pre-speech sentence planning (Lee & Thompson, 2011; Lindsley 1975) and, more interestingly, that verbs seem to be planned before the utterance of objects but not before the utterance of subjects. In other words, subjects are planned before but objects are planned after verbs (Momma et al., 2016, 2018). Momma et al. (2018) used a picture-word interference paradigm to study the timing of verb planning in unaccusative and unergative sentences. They observed that more advance planning is required to produce unaccusative than unergative sentences. Momma and colleagues propose that this is because the subject of unaccusatives has object-like properties, while the subject of unergatives is unambiguously a 'subject-agent'. Assuming that the subject of unaccusative verbs has an object-like nature (as the Unaccusativity Hypothesis claims), advance planning should take place at the very onset of unaccusative sentences, even before the subject (with object-like properties) is produced, but not at the onset of unergative sentences (which take no object) or transitive sentences (where the object is both linearly positioned and temporally appears later in the sentence). This would explain why we observed later SOTs for Spanish unaccusatives than unergatives, but it raises a new question: why did we find no statistically significant difference between transitive and unaccusative verbs (although SOTs in the transitive condition were numerically faster than unaccusatives)? It is

possible that other features defining transitivity, such as the higher number of arguments, could counteract the hypothesized facilitation for transitives relative to unaccusatives. For example, processing a transitive verb that appears on screen requires access to detailed syntactic and thematic information for both arguments, and this slows down speech onset. This slowdown would not be as large for unergatives since they only require one argument, but will be more substantial for unaccusatives, whose object-like subject occurs first in the sentence (both linearly and temporally), requiring advance planning before speech onset can take place.

An alternative explanation for the difference in SOTs between unaccusatives and unergatives could be the frequency or relatedness of retrieved subjects, i.e., subjects for the experimental unergative verbs could have been easier to retrieve than subjects for the unaccusative verbs due to frequency or relatedness to (primed by) the experimental verbs (e.g., the verb *to bloom* might prime the subject *a flower*). However, when statistically comparing the frequency of the first 20 common nouns used most often as subjects across the two conditions, we found no significant difference in their logarithmic frequency of use and we also did not observe any differential patterns of condition specific priming across the three verb groups.

If the distinction between verb groups is indeed realized in selective advance planning, this begs another question: why did we observe this difference for SOTs in Spanish but not in Basque? One explanation could be the overall increased difficulty of Basque unergatives. As discussed above, Basque unergatives are an intransitive type of verb that selects ergative morphology and transitive auxiliary common to transitive structures; we argue that this “apparent mismatch“ between the intransitive meaning of unergatives and their morphology typical of transitive verbs might increase their processing costs. Supporting this idea, error rates for the Basque sentence production

task did show that participants were more likely to produce ungrammatical structures when presented with unergative verbs. Moreover, the results of Martinez de la Hidalga et al. (2019), which show increased processing costs for unergative sentences, also support this view. We may have found no SOT differences between the three sets of Basque verbs because each group was processing costly for a different set of reasons: unergatives due to their "apparent transitive morphology mismatch", unaccusatives due to their non-canonical thematic mapping and planning-related demands and transitives either because of their additional ergative case marking, greater number of arguments or combination of both.

Furthermore, the SOTs in Basque were overall almost 0.5 s slower than the Spanish SOTs, suggesting that sentence production in Basque is more processing and/or planning costly regardless of verb type. We believe that the overall longer SOTs in Basque may reflect an interplay between AS processing requirements on the one hand and planning-related constrains on the other. A recent study by Egurtzegi and colleagues (2022), used SOTs in combination with eye-tracking and event-related neural synchronization to explore planning strategies during production of ergative-marked, transitive and unmarked, intransitive sentences in Basque and German. Their results suggest that speakers need to decide on case marking early on when planning to produce sentences with ergative subject inflection, while the utterances with unmarked subject do not pose the same demands, allowing delay in structural commitment and leading to slower SOTs. Crucially, when more factors are at play (in our case different dimensions of AS complexity and planning constrains related to ergative case marking), it is unfeasible to disentangle to what extent each of these factors is at play solely based on SOT measures. To better understand the relationship between sentence planning and AS processing and in an attempt to better describe mechanisms of advance planning in

ergative-absolutive languages, further cross-linguistic studies are needed that contrast ergative-marked and unmarked sentences in a more on-line fashion (e.g., with the use of eye-tracking or other methods more sensitive to temporal aspects of sentence processing and planning).

To test if the two languages indeed behave differently, we conducted an additional interaction analysis between verb type and language (see Table S7, Supplementary materials). Our results showed an interaction between language and type, which supports our view that languages can differ with respect to the processing cost for different verb types. Specifically, higher processing advantage for unaccusative verbs, shown in several languages with nominative-accusative alignment, is not present in Basque, a language with ergative-absolutive alignment.

We also entertained one alternative explanation that there is simply more variability across participants in Basque than Spanish due to greater individual differences in Basque exposure and/or grammatical proficiency. Under this hypothesis, SOTs to the different verb types would be expected to change as a function of participants' individual exposure to Basque or as a function of grammatical proficiency. We tested this hypothesis in an additional exploratory analysis by adding exposure to Basque and grammatical proficiency in Basque as predictors together with verb type (see Table S6b, Supplementary materials). The results suggest that neither exposure nor proficiency modulate SOTs, therefore the failure to find difference between different verb types in the Basque is unlikely due to individual variability in exposure or grammatical proficiency.

4.4. Error rates and SOTs: the non-convergent results

One of the interpretative challenges the presented results pose are the non-convergent error rate and SOT patterns within each language: the higher processing cost for Basque unergatives in the error rate analysis is not supported by the SOT results in Basque and, vice versa, the higher SOTs for Spanish unaccusatives are not supported by the error rate patterns in Spanish. Although these patterns are not in mutual contradiction, they are also not reinforcing each other. We attempted to provide an explanation for the null results in Basque SOTs as the possible interaction of various factors at play (i.e., different dimensions of AS complexity and planning constrains related to ergative case marking) and we attributed the null results in the Spanish error rate analysis to the ceiling effect caused by language-specific factors as well as participants' high proficiency. Nevertheless, these null results do not provide direct support for the effects that we present as evidence that the two languages pattern differently in terms of AS processing. Hence, the presented results should be understood as initial evidence pointing to possible AS processing differences between the two languages and as a prompt to encourage further research in this area. In an attempt to better understand the relationship between ergative case marking and verb AS processing in Basque and other ergative-absolutive languages, further cross-linguistic studies that contrast verbs of different AS complexities and study their processing cost and planning strategies in a more time-course sensitive fashion, are needed.

4.5. Limitations

The results reported may suffer from some further limitations related to cross-language and cross-dialectal interference as well as the auxiliary alternations in Basque that will be addressed in this section.

We acknowledge that possible cross-language transfer from Spanish to Basque might have contributed to the increased error rate for specific items in the unergative group. Given that our bilingual participants were more proficient in Spanish, it is possible that Spanish AS influenced the way they semantically (and phonologically) processed certain similar verbs in Basque. This could have contributed to some of the grammatical errors produced by our participants, especially the omission of ergative case marking. Unfortunately, there are no monolingual Basque speakers whom we could compare to Basque-Spanish bilinguals to provide more insight into the contribution of Spanish AS realization and its possible competition with the Basque reading of specific verbs.

Another possible limitation relates to the cross-dialectal influence in Basque. There is variability across dialects of Basque when it comes to auxiliary and case assignment by some intransitive verbs. For example, agentive verbs like *bazkaldu* (have lunch) or *afaldu* (have dinner), which we categorized as unergative based on our auxiliary acceptability test and that are typically used with ergative subject marking and transitive auxiliaries in Central and Western dialects, have unaccusative properties (intransitive auxiliary, zero subject case marking) in Eastern dialects (Pineda & Berro, 2020). Although this variability could have hypothetically affected our results, none of the participants reported using any of the Eastern dialects. Furthermore, closer examination of these specific verbs showed that they were not particularly problematic in our study (see Figure S2, Supplementary materials). However, as apparent from the auxiliary acceptability ratings (see *2.2 Stimuli* for details), there is relatively high variability amongst Basque speakers in their use of auxiliaries independent of dialectal variation which certainly might have impacted our results and has to be addressed as limitation.

Another important factor that could have potentially affected our results are auxiliary alternations present in certain syntactic environments in Basque. In our tasks, we presented each verb with a pre-selected and inflected auxiliary. This measure was adopted to disambiguate potentially conflicting readings of verbs in Basque. Many transitive verbs can be used with both *izan* and *ukan* as auxiliaries with consequences for internal AS. For example, some transitive verbs in Basque can also appear with the auxiliary *izan* in impersonal structures (e.g., *Eskola honetan, gizalegea irakatsen* ***da*** / *In this school, they teach good manners*). Furthermore, the auxiliary *izan* is also used in the progressive tense of all verb types regardless of their transitivity (e.g., *Liburua idatzen ari* ***da*** / *He is writing the book*). It is thus possible that providing a specific auxiliary might have created confusion or conflicts among different readings of verbs in Basque, whereas the same type of conflict could not be encountered in Spanish. We acknowledge the use of inflected auxiliaries together with the lexical verb as a possible limitation of our design.

Conclusion

To our knowledge, this study is the very first attempt to explore AS processing in fully proficient bilinguals of two languages with different morpho-syntactic alignment patterns, while using carefully matched stimuli in the within-subject design. This design, despite imposing certain limitations such as cross-linguistic influence, reduces the risk of individual differences impacting the results.

To sum up our findings, the null results in the lexical decision task for both languages suggests that the effects of AS complexity might be more prominent in the production modality. These effects might also be task sensitive, emerging in more

complex, sentence level tasks rather than single word tasks that require lexical access only.

Our results from the Basque sentence production task partially support our initial hypothesis: Basque unaccusatives would be easier to process than either unergatives or transitives. Our findings show that not only unaccusatives but also transitives are less likely to elicit ungrammatical sentences than unergatives. We argue that this is due to a feature of Basque unergatives that we refer to as "apparent mismatch", in which intransitive verbs select an auxiliary and case marking used in transitive sentences.

Our results in the Spanish sentence production task indicate that Spanish behaves like most languages studied to date: unaccusatives were more costly to process and produce than unergatives. We argue that the longer SOTs observed in Spanish unaccusatives reflect advance planning for unaccusative subjects with object-like properties. The results in Basque do not show the same increased SOTs for unaccusatives, which is a significant finding, suggesting that languages can differ with respect to the processing cost for different types of verbs. This finding is especially compelling because the same speakers are compared across languages and differences between languages cannot be attributed to individual variability, nor can they be reduced to proficiency and exposure differences that were ruled out in the additional exploratory analyses.

Overall, our findings provide initial evidence that languages with ergative-absolutive case alignment may not pattern alike in terms of AS processing with more commonly studied nominative-accusative languages. Nevertheless, the within-language error rate and SOT results do not provide convergent patterns and future research will be needed to corroborate cross-linguistic AS processing differences presented in our

study. Future investigators, ideally with the use of more time-course sensitive methods, will also need to tease apart various factors involved in AS processing of languages with ergative-absolutive alignment, namely planning required for ergative case marking and its interplay with processing demands associated with various levels of AS complexity. Finally, we would like to highlight the value and importance of studying languages with nominative-accusative alignment in contrast to ergative-absolutive languages with morpho-syntactic patterns that can help us better understand various cross-linguistic factors involved in AS processing.

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[i] Verbs can be categorized as unergative or unaccusative based on their lexical-semantic representation. According to Sorace (2000), predicates expressing *change of location, change of state, continuation of pre-existing state or existence of state* tend to be unaccusative, verbs of *uncontrolled process* and *controlled process (motional or non-motional)* are usually unergative.

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Content

1. Diagnostic tests

Table S1. The following set of syntactic tests has been used to categorize the Spanish verbs (some of these constructions only allow unaccusatives, others only allow unergatives).

Test	**Spanish example**	**Source**
1) pre-verbal vs. post-verbal subject	*Juan habló. vs.* **habló Juan*	Contreras, 1991
2) absolutive constructions	*caídas las piedras del cielo, los geólogos comenzaron a investigar las* vs. **hablados los turistas, se fueron de paseo al centro*	de Miguel, 1992
3) bare plural as post-verbal subject	*salieron marineros vs. *caminaron mujeres*	Torrego, 1989
4) adjectivisation	*una chica muerta* vs. **una chica tosida*	-
5) *de todo* constructions	*Ilegó de todo* vs. **nadó de todo*	-

2. Stimuli

Table S2. The Basque and Spanish stimuli lists with English translations; Note that the English translations of the verbs are in finite form, e.g., *last*, while the verbs used in the original stimuli list were in the present perfect tense, e.g., *has lasted*, which corresponds to *pretérito perfecto compuesto* in Spanish and to the infinitive plus present-tense auxiliary verb form in Basque.

BASQUE						
	UNERGATIVE		UNACCUSATIVE		TRANSITIVE	
1	**iraun du**	(last)	**desagertu da**	(disappear)	**irakatsi du**	(teach)
2	**bazkaldu du**	(lunch)	**jabetu da**	(come to realize)	**segitu du**	(follow)
3	**afaldu du**	(dine)	**jausi da**	(fall)	**erakarri du**	(attract)
4	**gosaldu du**	(breakfast)	**kostatu da**	(cost)	**galarazi du**	(cost)
5	**dantzatu du**	(dance)	**harrotu da**	(swell)	**maitatu du**	(love)
6	**funtzionatu du**	(function)	**kexatu da**	(worry)	**gidatu du**	(drive)
7	**xuxurlatu du**	(whisper)	**moteldu da**	(fade)	**leundu du** [3, 4]	(deliver)
8	**erregutu du**	(pray, beg)	**belaunikatu da**	(kneel)	**epaitu du**	(judge)
9	**emigratu du**	(emigrate)	**irristatu da**	(slide)	**txukundu du** [3]	(straighten)
10	**usaindu du**	(smell)	**biratu da**	(spin)	**arrastatu du** [3]	(pull)
11	**irakin du**	(boil)	**existitu da**	(exist)	**oparitu du**	(offer)
12	**paseatu du**	(walk)	**izoztu da**	(freeze)	**tiratu du**	(pull)
13	**bidaiatu du**	(travel)	**deuseztatu da**	(become weaker)	**xurgatu du**	(slurp)
14	**erauntsi du**	(rumble)	**zendu da**	(pass away)	**informatu du** [3, 4]	(inform)
15	**flotatu du**	(float)	**errenditu da**	(surrender)	**entrenatu du** [3, 4]	(train)
16	**biziraun du**	(survive)	**kulunkatu da**	(waver)	**kotizatu du**	(quote)
17	**desfilatu du**	(parade)	**matxinatu da**	(rebel)	**mailegatu du**	(loan)
18	**elurtu du**	(snow)	**bakartu da**	(withdraw)	**desestali du**	(reveal)
19	**eskiatu du**	(ski)	**izerditu da**	(sweat)	**frenatu du**	(brake)

SPANISH						
	UNERGATIVE		UNACCUSATIVE		TRANSITIVE	
1	**ha hablado**	(speak)	**ha caído**	(fall)	**ha recibido**	(receive)
2	**ha vuelto**	(return)	**ha muerto**	(die)	**ha creído** [3]	(think/believe)
3	**ha jugado**	(play)	**ha aparecido**	(appear)	**ha explicado**	(explain)
4	**ha corrido**	(run)	**ha huido**	(escape)	**ha comprado**	(buy)
5	**ha andado**	(walk)	**ha ocurrido** [1]	(occur)	**ha querido**	(want)
6	**ha llorado**	(cry)	**ha crecido**	(grow)	**ha traído**	(bring)
7	**ha caminado**	(walk)	**ha desaparecido**	(disappear)	**ha cortado** [3]	(cut)
8	**ha sonreído**	(smile)	**ha sucedido**	(happen)	**ha mandado** [3]	(order/send)
9	**ha nadado**	(swim)	**ha surgido**	(emerge)	**ha confesado**	(confess)
10	**ha temblado**	(shiver)	**ha faltado**	(lack/fail)	**ha forzado**	(force)
11	**ha rezado**	(pray)	**ha chocado**	(crash)	**ha saludado**	(greet)
12	**ha ladrado**	(bark)	**ha florecido**	(bloom)	**ha puesto**	(put)
13	**ha sangrado**	(bleed)	**ha salido**	(leave)	**ha invitado**	(invent)
14	**ha gritado**	(scream)	**ha fallecido**	(die)	**ha encendido**	(turn on)
15	**ha tosido**	(cough)	**ha soñado**	(daydream)	**ha costado** [2]	(cost)
16	**ha aullado**	(howl)	**ha expirado**	(expire)	**ha animado** [3]	(encourage)
17	**ha peleado**	(quarrel)	**ha rebotado**	(bounce)	**ha buscado** [3]	(look for)
18	**ha paseado**	(stroll)	**ha desfallecido**	(falter)	**ha empujado**	(push)
19	**ha estornudado**	(sneeze)	**ha sonado**	(ring)	**ha regalado**	(gift)

[1] This verb was discarded from the analysis for accidental misspelling.
[2] Although this verb is categorized as intransitive by RAE (Real Academia Española), it does require a direct complement and hence we decided to group it with obligatorily transitive verbs.
[3] These verbs are optionally transitive compared to the rest of the group that is obligatorily transitive.
[4] These verbs allow causative alternation, but only with auxiliary *izan*, which was not used in the stimuli presentation.

3. Psycholinguistic variables

Table S3. Mean and SD values for the three verb groups (unaccusatives, unergatives, transitives) in each language (Spanish, Basque) and in the four psycholinguistic categories that were balanced within each language; F = *F*-values, p = *p*-values of the one-way ANOVA comparison for each language and psycholinguistic variable.

	log. frequency		**length**		**orthographic neighborhood**		**Levenshtein distance**	
Spanish	*mean*	*SD*	*mean*	*SD*	*mean*	*SD*	*mean*	*SD*
unergative	0.87	0.77	7.10	1.20	9.58	4.11	0.22	0.20
unaccusative	0.95	0.66	7.63	1.98	8.47	4.05	0.23	0.20
transitive	1.16	0.50	7.47	0.96	9.23	3.56	0.25	0.24
ANOVA	F	*p*	F	*P*	F	*p*	F	*p*
	1.05	.36	0.66	.52	0.41	.66	0.09	.91
Basque	*mean*	*SD*	*mean*	*SD*	*mean*	*SD*	*mean*	*SD*
unergative	0.55	0.70	7.53	1.35	1.00	1.49	0.36	0.30
unaccusative	0.74	0.55	7.63	1.71	1.68	1.97	0.29	0.22
transitive	0.78	0.51	7.53	1.17	0.79	1.03	0.36	0.28
ANOVA	F	*p*	F	*p*	F	*p*	F	*p*
	0.83	.44	0.03	.97	1.74	.19	0.41	.67

4. Grammar tests

Appendix S4. The following tests in Spanish and Basque were developed for the purpose of this study and administered during our experiment; correct responses are in bold.

Spanish grammar test

1. ¿Cuál es la frase CORRECTA?
    a. Cuatro de cada cien personas lleva una mala alimentación.
    b. La gente en Andalucía es muy abierta.
    c. La mayoría de personas en Donostia hablan euskera.
    d. Le tengo envidia a mis compañeros de trabajo.

2. Enrique siempre reflexiona las cosas más cruciales de su vida _____.
    a. con sí mismo
    b. con si mismo
    c. consigo mismo
    d. con él mismo

3. ¿Cuál es la frase CORRECTA?
    a. Si tendría más tiempo, escribiría un libro sobre alimentación.
    b. Si quisieras ayudarme con la reforma, ya lo habrías hecho.
    c. Estaría bien que vengas a cenar a casa el viernes.
    d. Ya tendría cuatro hijos si me habría casado más joven.

4. Si yo _____ presidente, no _____ piedad con la corrupción.
    a. Sería / tendría
    b. Fuera / tendría
    c. Fuera / tuviera
    d. Soy / tendría

5. Tienes que ser responsable, no puedo estar todo el día _____
    a. detrás de ti.
    b. detrás tuya.
    c. por detrás de tí.
    d. por detrás tuya.

6. ¿Cuál es la frase CORRECTA?
    a. No me gustan las manzanas, si no las fresas. Si no hay fresas, prefiero cerezas.
    b. No me gustan las manzanas, sino las fresas. Si no hay fresas, prefiero cerezas.
    c. No me gustan las manzanas, sino las fresas. Sino hay fresas, prefiero cerezas.
    d. No me gustan las manzanas, si no las fresas. Sino hay fresas, prefiero cerezas.

7. ¿Cuál es la frase CORRECTA?
    a. Estoy seguro que me va a gustar tu casa.
    b. Seguro de que te sale bien el examen.
    c. Me alegro que me hagas esa pregunta.
    d. Había engordado hasta el punto de que no le reconocíamos.

8. ¿Cuál es la frase INCORRECTA?
    a. A la marquesa de Llanzol la han visto en compañía de Cristóbal Balenciaga.
    b. Él solamente le pedía poder estar cerca de ella.
    c. Comunicó a la diputada que no podía recibirle.
    d. Los empleados del hotel la oyeron gritar acaloradamente.

9. Elige la frase CORRECTA teniendo en cuenta que viste a una chica besando a otro chico.
    a. Le vi besarle
    b. Le vi besarlo
    c. La vi besarlo
    d. La vi besarla

10. ¿Cuál es la frase CORRECTA?
    a. Resbaló con el suelo mojado, golpeándose la cabeza contra el suelo.
    b. Se sometió a votación la enmienda, aprobándose por unanimidad.
    c. El escritor estudió en Madrid, yéndose después a Soria.
    d. Se conocieron en abril de 2013, casándose un año después.

11. No entiendo _____ te pones tan pesado algunas veces.
    a. porque
    b. por qué
    c. porqué
    d. por que

12. ¿_____ te crees que vas? Yo quiero ir _____van todos los demás.
    a. Donde / a dónde
    b. A dónde / adonde
    c. Dónde / adónde
    d. A donde / a donde

13. Espero que el profesor no _____ decidido suspender a todos los alumnos de _____ aula.
    a. Haya / esta
    b. Halla / esta
    c. Haya / este
    d. Halla / este

14. Yo he _____ una tortilla de patatas para la fiesta. Me sale estupenda porque no le _____mucha sal.
    a. hecho / hecho
    b. echo / echo
    c. echo / hecho
    d. hecho / echo

15. ¿Cuál es la frase CORRECTA?
    a. Haber si el viernes voy a ver la exposición de Cézanne.
    b. Me han dicho que debe de a ver muchos cuadros impresionantes.
    c. Haber estudiado Historia del Arte me ayuda a apreciarlos mejor.
    d. ¡Haber si no me arrepiento de haber venido!

16. ¡_____! _____ que ver cuánta basura tienes acumulada.
    a. Ay / Ahí
    b. Ahí / Hay
    c. Hay / Ahí
    d. Ay / Hay

17. _____el mantel y las servilletas. _____ bien la mesa es muy importante.
    a. Colocad / Poned
    b. Colocar / Poned
    c. Colocar / Poner
    d. Colocad / Poner

18. _____mucha gente en el concierto de Muse, pero no _____ muchas personas que se supieran las canciones.
    a. Habían / habían
    b. Había / había
    c. Había / habían
    d. Habían / había

19. No _____ digas a tus hermanos que Mikel _____ido a la discoteca.
    a. le / ha
    b. les / a
    c. les / ha
    d. le / a

20. ¿Cuál es la frase CORRECTA?
    a. Hoy me he enterado de que ayer dijistes que vendrías a visitarnos esta semana.
    b. Cuando viniste a mi casa la semana pasada mi amigo se enteró que estabas casada.
    c. No me gustaría tener que recordártelo, pero me prometiste que me devolverías el dinero que te presté. ¡No hagas como que no te enteras de nada!
    d. La situación política en España no es la misma que cuando te fuistes a vivir a Inglaterra, ¿no te has enterado que ha habido elecciones anticipadas?

Basque grammar test

1. Gidabaimena ateratzea hain erraza _____ez_____hainbeste lagunek huts egingo.
   a. bada / du
   b. balitz / luke
   c. balitz / zute
   d. nbalitza / luken

2. Interes zientifikoa_____interes publikoa ere badute ikerketa-lanek.
   a. baino
   b. **ez ezik**
   c. ezik
   d. bestela

3. Zein dago ZUZEN?
   a. Ipar Euskal Herriko hainbat sektore bultzatzen dute lan hori.
   b. Ipar Euskal Herriko hainbat sektoreek bultzatzen dute lan hori.
   c. Ipar Euskal Herriko hainbat sektorek bultzatzen dute lan hori.
   d. Ipar Euskal Herriko hainbat sektoreak bultzatzen dute lan hori.

4. Presondegi horretan HIESa oso zabaldua dago: hiru _____batek omen du.
   a. presoetatik
   b. presoengandik
   c. presorengatik
   d. presotatik

5. Zein dago ZUZEN?
   a. Liburuaren laburpena egin zidazun esan banizun, egitea zeneukan eta kitto!
   b. Liburuaren laburpena egitea esan banizun, egitea zeneukan eta kitto!
   c. Liburuaren laburpena egin zeniedazula esan banizun, egitea zeneukan eta kitto!
   d. Liburuaren laburpena egin zeniezadala esan banizun, egitea zeneukan eta kitto!

6. Zein dago ZUZEN?
   a. Otoiz egizue horrelako ezbeharrik gerta ez diezagun.
   b. Otoiz egizue horrelako ezbeharrik gerta ez dakigun.
   c. Otoiz egizue horrelako ezbeharrik gerta ez zaigun.
   d. Otoiz egizue horrelako ezbeharrik gerta ez zaigula.

7. Mutilek _____harrikoa _____ nahi izaten zuen amak.
   a. arrebari / egiten lagun zitzaten
   b. arrebei / egiten laguntzeko
   c. arrebeei /egiten lagun diezaien
   d. arrebei / egiten lagun ziezaieten

8. Ez dut ezagutu hura _____egun berorik. Halere, kutxak igotzeko _____ kemena izan nuen.

a. bezalako / bezain
b. bezain / besteko
c. adinako / adina
d. besteko / bezainbat

9. Zein dago ZUZEN?

a. Lorategiaren erdian egon arren, ez zuen inondik inora arrosarik ikusten.
b. Lan gehixeago egiten merezi du, emaitza askoz hobea izango da eta!
c. Datorren urtean ez zuen autoz aldatzeko aukerarik izan.
d. Nire ustez pilota-partidu hori ez dela oso ikusgarria izango.

10. Emango _____ pozik, zuk zeureak utziko _____ !

a. Nizun / bazenizkidan
b. Dizkizut / bazenizkit
d. **Nizkizuke / bazenizkit**
c. Nizkizun / bazenit

11. Ez dakit _____ izango diren opil hauek, baina bat hartuko dut.

a. Norentzat
b. Zeinentzako
c. Norentazako
d. Zeintzuentzako

12. Ez _____ joan esan nion, edozen gauza gerta _____.

a. Zedila /dakiola
b. Dadila/zekiola
c. Zedila / zekiokeela
d. Bedi /dakiokeela

13. Urte asko _____ da Donostiako etxe horretan _____ ginenetik.

a. Pasatu / bizi izan
b. Pasa izan / bizitzen
c. Pasatu / bizitzen
d. Pasa / bizi izaten

14. Zein dago GAIZKI?

a. Lau neskarekin etorri da.
b. Hainbat mutilei kontatu diezu hori.
c. Mezatara joan da gure semea.
d. Zein da animaliarik ederrena?

15. Zein dago ZUZEN?

a. Ehun umetatik hogei elebidunak dira.
b. Umeen ehuneko hogeiak elebidunak dira.
c. Ehuneko umeetatik hogei elebidunak dira.
d. Ehuneko hogei ume elebiduna da.

16. Eta zuk zer egingo _____ oporrak oraintxe emango_____?
    a. Zenuken / balizkizukete
    b. Zenukeen / balizute
    c. Zenuen / bazizkizuten
    d. Zenuke / balizkizute

17. Zein dago ZUZEN?
    a. Gustura joango nintzen atzoko afarira, baina ezin nintzateke joan.
    b. **Gustura joango nintzen atzoko afarira, baina ezin izan nintzen joan.**
    c. Gustura joango nintzen atzoko afarira, baina ezin nuen joan.
    d. Gustura joango nintzen atzoko afarira, baina ezin ninteke joan.

18. Lagunek baztertu egin_____eta zuek oso haserre erantzun_____
    a. dizuete / diozue
    b. zaituzte / diezue
    c. zaituztete / diezue
    d. zaizkizue / dizuete

19. Zein dago ZUZEN?
    a. Edaten uzten ez baduzu zirrosiak jota bukatuko duzu.
    b. Edateak uzten ez baduzu zirrosiak jota bukatuko duzu.
    c. Edateari uzten ez badiozu zirrosiak jota bukatuko duzu.
    d. Edan uzten ez baduzu zirrosiak jota bukatuko duzu.

20. Zein dago ZUZEN?
    a. Bihar zinemara joan ahal izango ginateke.
    b. Bihar zinemara joan gintezke.
    c. Bihar zinemara joan dezakegu.
    d. Bihar zinemara joan ezin ahal

5. Subject omission analysis

In this section we tested how subject omission in the sentence production task affects the SOTs in Spanish (Table S5a) and Basque (Table S5b). This analysis was performed to exclude the possibility that the inclusion of the sentences where the subject was omitted differentially affected the SOTs across the three verb types.

Table S5a. Spanish SOT analysis: comparison of model with the verb type only and with the verb type plus the subject omission; the subject omission did not improve model fit.

model 1	**lmer** (log(SOT) ~ verb type (1|subject) + (1|item))	
model 2	**lmer** (log(SOT) ~ verb type + subject omission + (1|subject) + (1|item))	
anova	**Chisq**	***p*-value**
	0.573	.449

Table S5b. Basque SOT analysis: comparisons of the model with the verb type only, with the verb type plus the subject omission and their interaction; the subject omission improved model fit but there was no interaction with verb type (this suggests that the subject omission contributed to shorter SOTs in the Basque sentence production task evenly across all the conditions and did not differentially affect the SOTs of different verb types).

model 1	**lmer** (log(SOT) ~ verb type + (1|subject) + (1|item))	
model 2	**lmer** (log(SOT) ~ verb type + subject omission + (1|subject) + (1|item))	
anova	**Chisq**	***p*-value**
	19.277	1.131e-05 *
model 2	**lmer** (log(SOT) ~ verb type + subject omission + (1|subject) + (1|item))	
model 3	**lmer** (log(SOT) ~ verb type * subject omission + (1|subject) + (1|item))	
anova	**Chisq**	***p*-value**
	4.0434	.1324

6. Exploratory analyses

Mean language exposure to Spanish or Basque[1] and grammatical proficiency in Basque[2] were included as predictors alongside verb type in a series of linear mixed-effect models to assess whether they improved model fit compared to the model in our main analysis, which only included verb type as predictor[3].

Table S6a. The results of the exploratory analysis of the error rates in the Basque sentence production task where the main model was compared to more complex models with additional individual difference variables for i) exposure to Spanish (= exposure_SP), ii) proficiency (= prof_BQ), and (if significant) their interaction with the verb type. The anova() output (chi-square and *p*-values) for the comparison of the more complex model with its less complex version is reported.

Sentence production task (Basque): Error rates		
	Exposure	
model 0	**glmer** (error ~ verb type + (1 + verb type|subject) + (1|item))	
model 1	**glmer** (error ~ verb type + exposure_SP + (1 + verb type|subject) + (1|item))	
anova (model 0, model 1)	**Chisq** 17.224	***p*-value** <.001 ***
	Exposure (interaction with verb type)	
model 1	**glmer** (error ~ verb type + exposure_SP + (1 + verb type|subject) + (1|item))	
model 1a	**glmer** (error ~ verb type * exposure_SP + (1 + verb type|subject) + (1|item))	
anova (model1, model1a)	**Chisq** 0.851	***p*-value** .653
	Exposure & Proficiency	
model 1	**glmer** (error ~ verb type + exposure_BQ + (1+ verb type |subject) + (1|item))	
model 2	**glmer** (error ~ verb type + exposure_BQ + prof_BQ + (1+ verb type|subject) + (1|item))	
anova (model1, model2)	**Chisq** 6.969	***p*-value** .008 **
model 2	**glmer** (error ~ verb type + exposure_BQ + prof_BQ + (1+ verb type|subject) + (1|item))	

contrast[4]	**Estimate**	**SE**	***z*-ratio**	***p*-value**
transitive : unaccusative	-0.497	0.547	-0.908	1.0000
transitive : unergative	-1.692	0.508	-3.332	.0022**
unaccusative : unergative	-1.195	0.361	-3.311	.0018**

Exposure & Proficiency (interaction with verb type)	
model 2	**glmer** (error ~ verb type + exposure_BQ + prof_BQ + (1+ verb type |subject) + (1|item))
model 2a	**glmer** (error ~ verb type * prof_BQ + exposure_BQ + (1+ verb type |subject) + (1|item))

anova (model2, model2a)	**Chisq** 0.918	***p*-value** .632

Table S6b. The results of the exploratory analysis of speech onset times (SOTs) in the Basque sentence production task where the main model was compared to more complex models with additional individual difference variables for i) exposure to Basque (= exposure_BQ) and ii) proficiency to Basque (= prof_BQ). The anova() output (chi-square and *p*-values) for the comparison of the more complex model with its less complex version is reported.

Sentence production task (Basque): SOTs		
	Exposure	
model 0	**lmer** (log(SOT) ~ verb type + (1|subject) + (1|item))	
model 1	**lmer** (log(SOT) ~ verb type + exposure_BQ + (1|subject) + (1|item))	
anova (model0, model1)	**Chisq** 0.057	***p*-value** .810
	Proficiency	
model 0	**lmer** (log(SOT) ~ verb type + (1|subject) + (1|item))	
model 2	**lmer** (log(SOT) ~ verb type + prof_BQ + (1|subject) + (1|item))	
anova (model0, model2)	**Chisq** 0.570	***p*-value** .450

[1] To compute exposure, we extracted self-reported exposure scores from the participants´ database, where daily usage (in percentage) of Basque/Spanish in writing speaking, reading, and listening was reported. Overall, participants experienced more exposure to Spanish than Basque (Spanish: mean = 51%, SD = 17, range = 12.5 - 90%; Basque: mean = 37%, SD = 17, range = 10 - 80%; $t = 3.45$, $p = <.001$).

[2] Grammar scores for each participant in each language were obtained from the Basque grammar tests designed specifically for this experiment and described in the Methods section (see Table 4 for the grammar scores and Appendix S4, Supplementary materials, for the grammar test content).

[3] We did not include other available measures of proficiency, e.g., LexTALE or BEST scores, because these are designed to measure vocabulary knowledge rather than grammatical aspects of language.

[4] Here we also report the emmeans() output for each verb type contrast after language exposure and proficiency were added to the best fitted model so as to demonstrate that their inclusion did not cancel out the effect of verb type.

7. Grammatical errors: Spanish and Basque

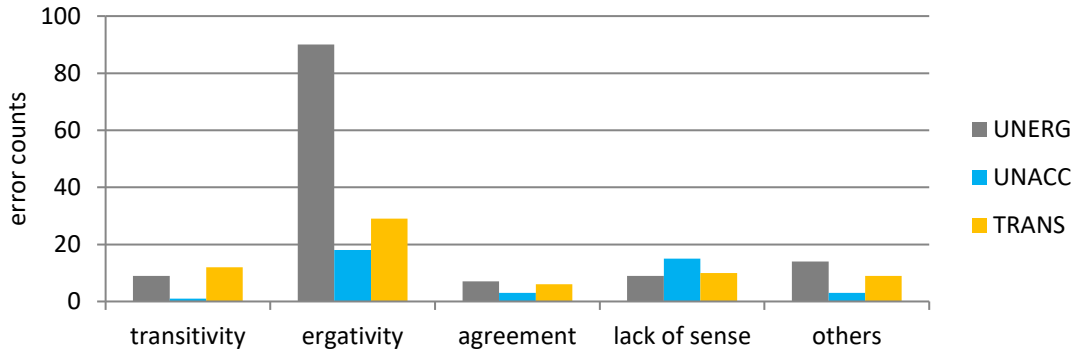


Figure S1a. Counts and types of errors detected in the Basque sentence production task; a) transitivity: an obligatorily transitive verb missing an object or intransitive verb with a redundant, ungrammatical object attached; b) ergativity: ungrammatical use or omission of ergative case agreement; c) agreement: other types of agreement errors; d) lack of sense: the expression does not make sense due to lexical errors; e) others: other types of errors, e.g., word order; some sentences contained more than one error, therefore the total count of errors in this figure is higher than the total count of ungrammatical sentences detected.

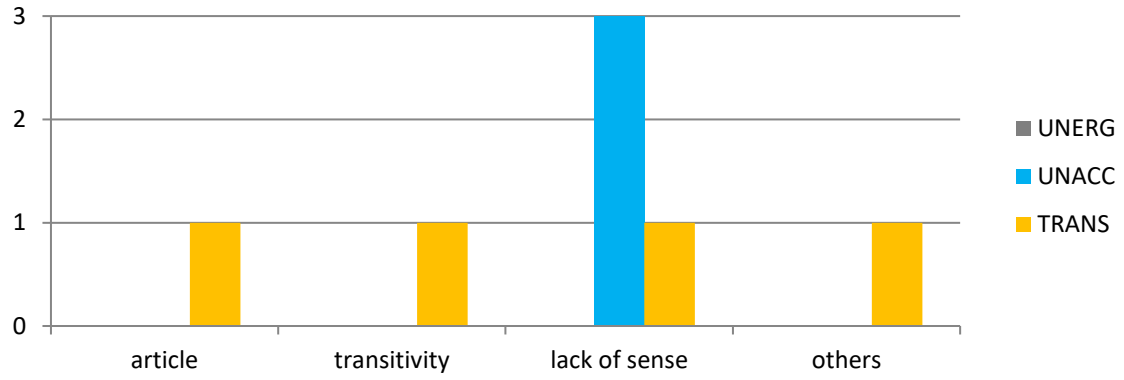
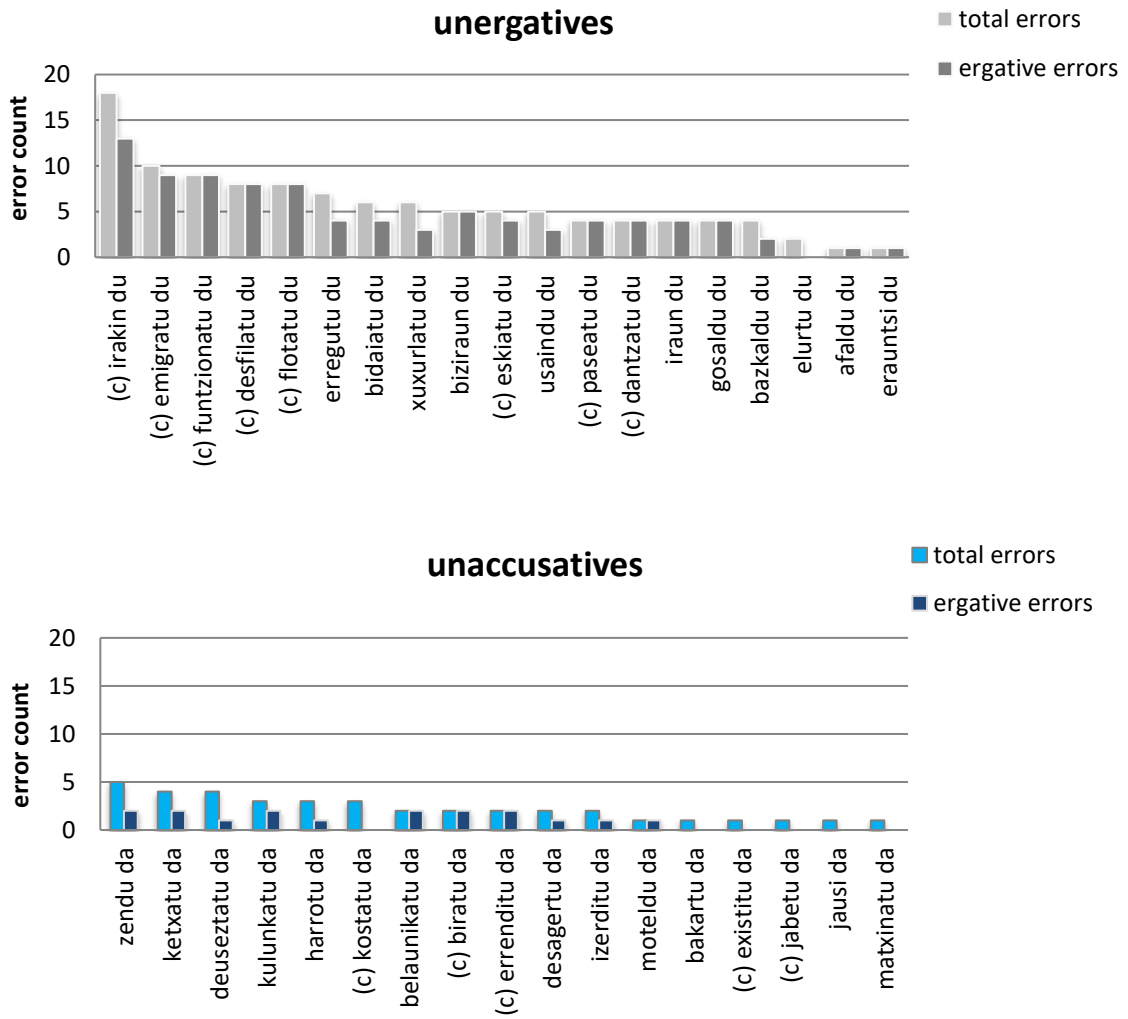


Figure S1b. Counts and types of errors detected in the Spanish sentence production task; a) article: omission of obligatory article; b) transitivity: an obligatorily transitive verb missing an object or intransitive verb with a redundant, ungrammatical object attached; c) lack of sense: the expression did not make sense due to lexical errors; e) others: other types of errors, e.g., word order; some sentences contain more than one error, therefore the total count of errors in this figure is higher than the total count of ungrammatical sentences detected.

8. Grammatical errors per item: Basque

The by-item descriptive analysis suggests that some unergative cognate verbs such as *desfilatu* (to parade), *emigratu* (to emigrate), *flotatu* (to float) or *futzionatu* (to function) were particularly susceptible to ergative case marking omissions (see Figure S2). However, other unergative cognates such as *eskiatu* (ski) or *paseatu* (to stroll) elicited error rates comparable to the non-cognates. Cognates in the transitive group, such as *tiratu du* (pull), did not seem to be particularly problematic either. This suggests that cognate status *per se* was not responsible for the tendency to omit ergative case marking. Indeed, the most problematic verb in the unergative group, *irakin* (to boil) is not a cognate.[1] However, it is apparent that certain items contributed to grammatical errors produced by our participants more than others.



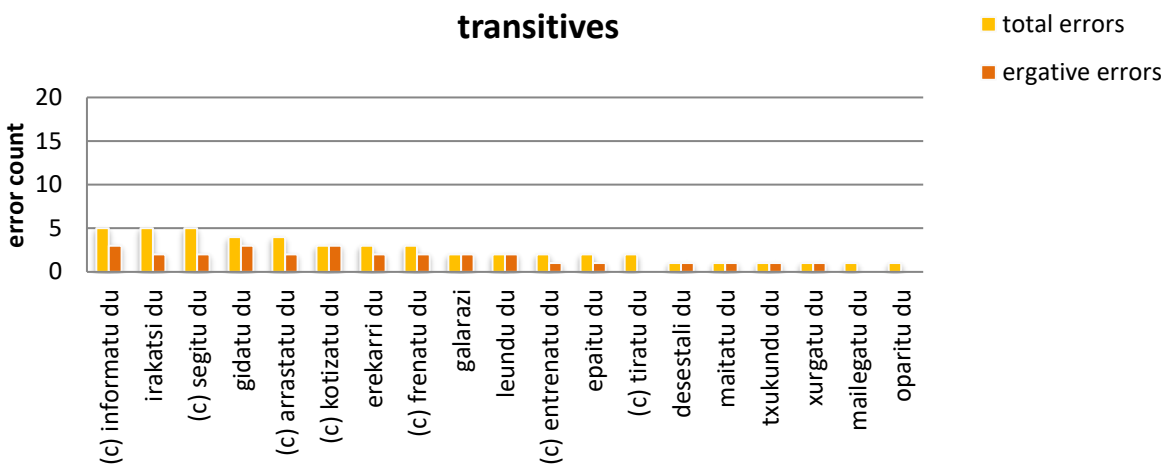


Figure S2. Light bars represent the total number of grammatical errors produced for each verb within the three verb groups (unergatives, unnacusatives, transitives); dark bars represent ergative case errors (e.g., ergative case marking omissions); verbs marked with (c) prefixes indicate cognate verbs as determined by Levenshtein distance.

[1] Nevertheless, it is important to point out that its Spanish translational equivalent *hervir*, like English *boil*, is typically classified as unaccusative (e.g., Bosque & Demonte, 1999; Perlmutter, 1978). The same is true for the above-mentioned verb *flotatu*, classified as unergative in Basque but typically considered unaccusative in Spanish. Although unaccusative-unergative classification of translational equivalents of verbs varies across languages and each language has different diagnostic tools for this classification, the mismatch in classification between these two languages could result in competition between unergative and unaccusative readings of the verb in bilinguals.

9. Interaction analysis

To test if Spanish and Basque elicit differential speech onset times (SOTs), we conducted an additional interaction analysis between verb type and language. In this analysis, we collapsed Basque and Spanish data sets from sentence production task and tested for the interaction of verb type and language factors.

Table S7. The results of the interaction analysis of SOTs in the sentence production task where the main model with verb type only (for both languages collapsed) was compared to the model that included language predictor and the comparison of models with and without the interaction of language and verb type. The anova() output (chi-square and *p*-values) for the comparison of the more complex models with their less complex versions is reported.

model 0	**lmer** (log(SOT) ~ verb type + (1|subject) + (1|item))			
model 1	**lmer** (log(SOT) ~ verb type + language + (1|subject) + (1|item))			
anova (model 0, model 1)	**Chisq** 14135.5	***p*-value** p < .001***		
model 1	**lmer** (log(SOT) ~ verb type + language + (1|subject) + (1|item))			
model 1a	**lmer** (log(SOT) ~ verb type * language + (1|subject) + (1|item))			
anova (model 1, model 1a)	**Chisq** 7.311	***p*-value** p < .026*		
Contrast[1]	**Estimate**	***SE***	***t*-value**	***p*-value**
verb typeTRANS	-1.237e-03	1.885e-02	-0.066	.948
verb typeUNERG	-1.524e-02	1.901e-02	-0.802	.425
languageSP	-2.402e-01	1.148e-02	-20.912	< .001 ***
verb typeTRANS : languageSP	-2.286e-02	1.605e-02	-1.424	.154
verb typeUNERG : languageSP	-4.368e-02	1.615e-02	-2.704	.007 **

[1] Here we report the summary of the best fitted model (model 1a) with the unaccusatives verb type as reference so as to demonstrate that the interaction inclusion did not cancel out the effect of verb type.