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Universidad del País Vasco   Euskal Herriko Unibertsitatea

ARGUMENT STRUCTURE PROCESSING IN BILINGUALS AND BILINGUAL SPEAKERS WITH APHASIA: A CROSS-LINGUISTIC INVESTIGATION

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Donostia-San Sebastián, 2023

The work presented in this dissertation was funded by the Basque Government (grant numbers: PRE_2017_1_0098, PRE_2018_2_0073, PRE_2019_2_0114, PRE_2020_2_0234, EP_2021_1_0017).

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October 2023

Acknowledgements

As I am writing these lines, my newborn son is happily resting on my chest. It is our second child born during my PhD studies and the third one since I started pursuing higher education. Needless to say that with such an incredible abundance of blessings I never could have gotten to the point of finishing my PhD thesis without their father—the most beloved and important person in my life—**Andrew**. Not only has he been helping me raise our wonderful children and supporting me relentlessly during my PhD, but we also spent countless hours talking about my experiments, their results and implications. On top of that, he proof-read this thesis and gave me numerous insights on how to improve my writing. If there is anyone who deserves a big shout out for helping me out with this work and my deepest gratitude for always being there for me, it is you, Honey.

My PhD supervisors, **Drs. Simona Mancini** and **Manolo Carreiras** also deserve my great appreciation. Thank you so much, Simona, for being the always-there and always-helpful supervisor you were to me. Manolo, I am very thankful that in spite of being a busy director of our research center, you always found time to give me your valuable insights and advice on my work including this thesis. Additionally, **Dr. Mira Goral**, who hosted me in her lab during my international internship, deserves a big thank you. Mira, I am very grateful that you took on the role of my research-stay supervisor in spite of the challenging pandemic circumstances. All I learned about bilingual aphasia, I learned from you. Additionally, I would like to sincerely thank **Dr. Dirk den Ouden** and **Dr. Elena Barbieri**, who served as international reviewers of this thesis, allowing me to pursue the International Doctorate Mention.

My research would not be possible without an incredible team of dedicated research assistants, **Ainhoa**, **Itziar**, **Amets**, **Araitz, Aiora** and many others. Navigating through the funding applications, grant renewals and PhD studies was only viable with a great deal of help from **Ana** and **Eider**. I also wish to thank all the participants that took part in my experiments. Furthermore, I am very appreciative of the financial aid I received from the Basque Government and the BCBL to complete my PhD.

My special thanks further belongs to **Candice** for helping me administer tasks for English-Spanish bilinguals, to **Teresa** for her help with abstract translations, to **Andrew** and **Steph** for proof-reading and to **Dana** for teaching me how to code experiments in Python. Finally, I will always remember and hold dear the amazing colleagues I met in the BCBL, many of whom became my dear friends—**Dana**, **Ioanna**, **Sandra**, **Teresa, Candice**, **Jordi,** all the members of the **NLA group**—and many others with whom I crossed paths, engaged in many great conversations and spent countless precious moments while working on my PhD.

Abstract

Verbs are a central part of speech because they express who does what to whom, information referred to as argument structure information. Previous research has shown that costs associated with argument structure processing scale with the number of arguments and/or as a result of non-canonical argument mapping. Furthermore, increased difficulty associated with these factors has also been reported for persons with aphasia (PWA). Basque, a language with an ergative-absolutive case alignment system, assigns ergative case morphology to subjects of unergative and transitive but not unaccusative verbs. It is unclear if and how these case assignment patterns affect processing cost and performance on these verb groups that also vary in number of arguments and canonicity of argument mapping.

The present thesis investigates the influence of ergative case marking on argument structure complexity effects in both neurotypical Basque-Spanish bilinguals and bilingual PWA. The processing cost associated with ergative case in Basque is evaluated in parallel to Spanish and English, nominative-accusative languages that do not use case morphology to mark different types of verb argument structures. Three experiments were conducted to test the hypothesis that ergative case marking in Basque increases the processing cost of verbs and leads to differential argument complexity effects than those predicted for typically studied nominative-accusative languages including Spanish and English. Specifically, we predicted that ergative case assignment would inflict higher processing cost on those Basque verb groups that require ergative case (i.e., unergatives and/or transitives) as compared to those that assign absolutive case (i.e., unaccusatives). Spanish and English were expected to pattern alike, eliciting higher processing cost for transitives

due to the higher number of arguments and/or for unaccusatives due to their non-canonical argument mapping. A within-subject design was utilized in a population of simultaneous Basque-Spanish bilinguals (Experiments 1 and 2) and both a bilingual Spanish-English and a Basque-Spanish PWA (Experiment 3). Within these experiments, the speakers' performance on unergative, unaccusative and transitive verbs was tested across lexical-, sentence- and connected-speech levels of linguistic representation in both production and comprehension. The patterns of processing cost quantified via distinct behavioral measures were cross-linguistically assessed and evaluated.

Our results in neurotypical Basque speakers indicate that ergative-case markings significantly affect the processing cost of unergative verbs. This effect was observable both during sentence production via increased error rates and longer speech onset times (SOTs) elicited for unergatives when compared to other studied verb groups. We interpret this finding as the *apparent mismatch* between the intransitive semantics of unergative events and their transitive morpho-syntactic properties. In contrast, Spanish showed patterns consistent with English, i.e., unaccusatives elicited increased processing cost when compared to other studied verb groups, as demonstrated via the higher error rates they incurred in action naming and higher SOTs they elicited in both action naming and sentence production. The unaccusativity effects are interpreted as a result of non-canonical argument mapping.

With respect to the PWA, the Spanish-English bilingual PWA manifested intensified but qualitatively similar argument complexity effects to those in neurotypical speakers. The performance of the Basque-Spanish PWA goes against our predictions for Basque and her performance in Spanish does not align with patterns of neurotypical Spanish speakers or PWA speaking Spanish either. These mixed findings are interpreted as a consequence of her etiology or, alternatively, as a result of her relatively high performance on the tasks. Hence, the influence of ergative-case morphology on the performance of Basque speaking PWA is a possible avenue for future studies.

Overall, the present thesis brings novel evidence that languages with ergative-absolutive case alignment systems, like Basque, do not pattern alike with more commonly studied nominative-accusative languages in terms of argument structure complexity processing, calling for further cross-linguistic investigation. We further endorse cross-linguistic research on argument structure processing, especially in understudied languages like Basque, and stress out the need and importance of cross-linguistic approach to aphasia.

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List of acronyms

ASCH = The Argument Structure Complexity Hypothesis
BCBL = Basque Center on Cognition, Brain and Language
BEST = Basque, English and Spanish Test (de Bruin et al., 2017)
BF(s) = Bayes factor(s)
BSWQ = Bilingual Switching Questionnaire
CETI = The Communicative Effectiveness Index
ERPs = event related potentials
fMRI = functional magnetic resonance imaging
GLMEM(s) = general linear mixed-effect model(s)
LEAP-Q = The Language Experience and Proficiency Questionnaire
LMEM(s) = linear mixed-effect model(s)
NP(s) = noun phrase(s)
PWA = person(s) with aphasia
PWA1 = person with aphasia 1 (Spanish-English)
PWA2 = person with aphasia 2 (Basque-Spanish)
RTs = reaction times
SD = standard deviation
SOTs = speech onset times

Used in Examples, Tables and Figures

ABS = absolutive case
ACC = accusative case
AUX = auxiliary
BQ = Basque
CI = confidence interval
DO = direct object
EN = English
ERG = ergative case
IO = indirect object
NOM = nominative case
OBJ = object
PP = past participle
PPC = pretérito perfecto compuesto (= the Spanish equivalent of the present perfect tense)
SP = Spanish
SUBJ = subject
TRANS = transitives
UNERG = unergatives
UNACC = unaccusatives

Introduction

Verbs constitute a central part of speech, because they encode who does what to whom. For example, the verb "write" encodes a relation between someone who writes and something that is being written. This piece of information, supposedly stored in the verb's lexical entry, is referred to as argument structure information. Actions expressed by verbs are an anchor around which our representations of events are built. As such, verbs can be viewed as a core of both human language and event cognition.

This thesis is concerned with the distinct levels of complexity verbs entail. The central assumption of our investigation is the notion that lexical entries of verbs contain various types of argument structure information and the complexity of this information can affect the way in which they are processed by the human brain. Specifically, the present thesis examines cross-linguistic variations in case alignment systems and their impact on the processing of this information. It attempts to answer *if* and *how case morphology and its realization modulate the processing cost of argument structure information* and *what consequences it has for our understanding of argument structure representation and processing*.

Chapter I of the present thesis (Sections 1.1.–1.5.) reviews current linguistic theories and the psycholinguistic models attempting to describe and explain both the structural and the processing aspects of argument structure information. It reviews the selected language-specific aspects hypothesized to influence verb processing costs and summarizes relevant cross-linguistic evidence from both neurotypical and language-impaired speakers. Finally, based on the theoretical background provided, the main objectives, hypotheses, and predictions raised by and tested in this thesis are presented.

Chapter II consists of three experiments (Sections 2.1.–2.3.) designed to investigate cross-linguistic variations in argument structure processing related to morphological case alignment in both a neurotypical bilingual population of Basque-Spanish speakers (Experiment 1 and 2) and in two cases of bilingual persons with aphasia (PWA): a Basque-Spanish and a Spanish-English speaker (Experiment 3).

Chapter III provides a general discussion (Sections 3.1.–3.4.) which draws from the summarized theoretical background as well as from the results of the conducted experiments in an attempt to evaluate how manipulated cross-linguistic factors influence verb processing costs in the studied languages and populations. It also addresses relevant issues related to experimental settings and bilingualism and their potential impact on our results. The Conclusion summarizes the main findings and provides future directions for cross-linguistic research in argument structure processing.

Please note that Experiment 1 has been published in a peer reviewed journal (Heinzova et al., 2023), Experiment 2 is in preparation for submission and Experiment 3 has been submitted to a peer reviewed journal at the time of depositing the thesis. Since the present thesis comprises these three independent research papers, some of its content may overlap.

Chapter I. Theoretical Background

1.1. The verb as the core of language and cognition

This section reviews selected influential theories in linguistics, cognitive psychology, and clinical aphasiology that consider the verb/action and its relation to other sentence constituents/arguments to be the core of the human language system and thought. The purpose of this section is to highlight the essential role that the verb has played in our understanding of language structure and the structure of other non-linguistic, cognitive processes.

In his influential PhD thesis, Gruber (1965) introduced the study of *thematic relations* to generative grammar and among his insightful observations on syntactic relations he states: "It has become apparent that the verb is the principle variable in sentences upon which the syntactic form of the sentence depends" (Gruber, 1965, p. 4). His thesis extensively defines different thematic roles the verb can hold, setting the stage for further discussions on thematic roles and verb argument structure (for a discussion on Gruber's contribution to linguistics, see Jackendoff, 2015).

Only a few years later, Fillmore (1968) introduced a *case grammar* framework, where he defined a basic sentence structure as constituting a verb plus one or more noun phrases (NPs). In his framework, each NP holds various relations to the verb including an agent, a patient, an instrument, a locative, and others. Later, these relations, labeled as grammatical cases, would become known as thematic roles. According to Fillmore's approach, the verb is recognized as the central organizing predicate of the sentence (Fillmore, 1968; Fillmore, 1971).

Ever since these influential ideas were proposed, verb frames became a highly useful concept. The idea of organizing the constituents clustered around the verb by assigning them distinct roles started to be widely used in linguistics but also in artificial intelligence (see van Dijk & Kintsch, 1983, pp. 307–311) and cognitive psychology. For example, placing the verb frame at the core of the language system led models attempting to describe the human memory system (e.g., Rumelhart et al., 1972; Rumelhart & Norman, 1973; Rumelhart & Ortony, 1977) to propose that, in a similar manner, our knowledge and memory are also centered around actions. Rumelhart and Ortony (1977) suggested that the human information-processing system consists of *schemata*—basic building blocks stored as packages of information in our memory—that instantiate symbolic representations of human knowledge and link linguistic representations with our environment. According to this approach, *schemata* can be described as knowledge associated with concepts like "swimming" that also include all components related to these concepts (e.g., motor movements required to swim, liquid environments needed for swimming, etc.). In other words, *schemata* serve as mental frames that organize our knowledge in the long-term memory. Although, in Rumelhart and Orton's understanding, these concept-component relations were non-linguistic in nature, the authors assimilated them to the verb-NP relations as earlier described by Fillmore (1968). Note, that the idea of *schemata* as category-neutral semantic representations that link actors to events has recently been revived in a more current sentence comprehension model developed by Bornkessel-Schlesewsky and Schlesewsky (2013).

The foundational ideas that center our language and memory around the verb/action have also yielded fruit in developing clinical approaches to language disorders. Inspired by these verb-centric theories, Loverso and colleagues developed an aphasia therapy which stands on the "verb as a core" theoretical principle: "Most commonly, events of an individual's database (knowledge and memory) are represented by centering all language procedures around the action. Therefore, action, in our opinion, is the central node" (Loverso et al., 1988, p. 47). Hence, in their understanding of the language system, the authors conceptualize the linguistic category of the verb as fully corresponding to an action (i.e., verb = action) which constitutes a central node of language from which other nodes for actors (i.e., agents, instruments) and objects (i.e., recipient, object, etc.) spread out (Figure 1).

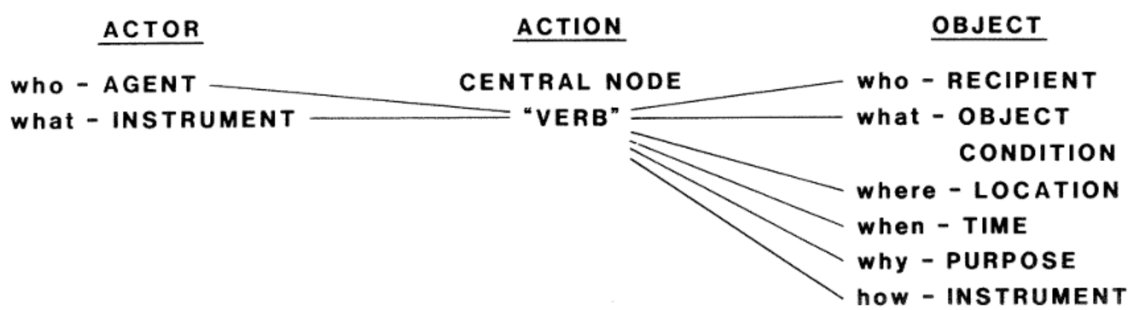


Figure 1. Language system based on the verb as the central node (Loverso et al., 1988).

Loverso and colleagues' therapeutic approach was founded on the notion that in order to understand and describe events, a speaker must first identify the relations between the described actions and the participating entities, which are then assigned various thematic roles, i.e., *an agent role* = who is performing the action, *a patient/theme role* = who/what is undergoing the action, *a recipient role* = who is the recipient of the action, and any other present relations. In the following years, numerous distinct verb-centered therapeutic approaches to verb-related deficits in aphasia were developed, such as Mapping Therapy, (Schwartz et al., 1994), Treatment of Underlying Forms (Thompson & Shapiro, 2005), Semantic Feature Analysis (Wambaugh et al., 2014) or Verb Network Strengthening Treatment (Edmonds, 2016), to name a few.

A verb-centered understanding of language systems was empirically supported by evidence in first language acquisition and adult speech comprehension studies summarized by Bever (1970). In his article, Bever described a basic sequential labeling strategy which speakers tend to use in an absence of further specific semantic information. During this initial comprehension strategy, speakers map any *noun-verb-noun* sequence to the thematic roles of *actor-action-object* (a phenomenon also referred to as a *noun-verb-noun* heuristic). Bever argued that this strategy, arising from our experience with language and generated by our inductive reasoning, establishes the primary internal structure of a sentence, present as a basic processing framework for sentence segmentation (Bever, 1970, pp. 298–302). Since language comprehension seems to heavily rely on our mental representations of the world (e.g., Anderson et al., 1977; van Dijk & Kintsch, 1983; Rumelhart, 1980; Zwaan, 1999), one could also interpret such a heuristic as a more general principle of human cognition which shapes how we represent events, relations within these events, and how these representations are expressed in our language (e.g., Hafri et al., 2018; Rissman & Majid, 2019). Indeed, even very young children seem to have pre-linguistic capacities that allow them to structure events based on assigning thematic roles to event participants (e.g., Bowerman, 1990; Wagner & Lakusta, 2009), implying a core knowledge system that guides us in assigning agents to actions (Spelke & Kintzler, 2007).

To sum up, the process of identifying the relations that participants have within the events in which they participate has been outlined as a central principle in an attempt to adequately describe the human language system. Moreover, this theoretical principle has also proven useful in our understanding of how people categorize and store information.

Finally, the identification and categorization of roles that participants have in particular events has been argued to constitute a portion of human core knowledge, essential in event cognition and integral to language learning and processing. Now, when we have outlined the central role that the verb and its relations to other sentence/event components seems to play in language and cognition, we can proceed to the linguistic definition of verb argument structure and to distinct linguistically relevant ways in which this structure can be viewed.

1.2. Verb argument structure: A linguistic account

This section provides a linguistic account of verb argument structure and of the nature of linguistic information stored in verbs' lexical entries which specifies the relations of verbs to their arguments. It shows how verbs can be categorized based on their distinct argument configurations and reviews selected linguistic theories and concepts relevant to the topic of the present thesis.

In simple terms, verbs describe events and verbal arguments represent actors that stand in distinct relations to these events. As Luzzati and Chireria put it: "A fundamental characteristic of verbs is that they are argument taking" (2002, p. 56) as they describe relations among the protagonists of events. In linguistics, the term *argument structure* typically refers to the lexical property of a verb that specifies the number of arguments, their syntactic and functional expression, and their thematic relations in an event expressed by the verb (e.g., Grimshaw, 1990; Jackendoff, 1990; Levin & Rappaport Hovav, 2005; Williams, 1981; among others). In other words, the argument structure of a verb specifies rules governing the syntactic, functional, and thematic environments, in which the verb can appear. For example, the verb *hit* in the sentence *the boy hit the dog* requires two arguments. From the syntactic point of view, these arguments are both noun phrases (1a).

Functionally, the first NP corresponds to the subject of the sentence, while the second NP to the object (1b). To fully describe the argument structure, we now need to define the semantic roles of the two arguments (*the boy*, *the dog*) as each have their specific semantic relation to the verb: *the boy* is "the hitter" and *the dog* is "the hittee" of the event (2a). At the same time, these two arguments are also instantiating more abstract, *thematic roles*: *an agent* and *a patient*. In our example, the agent role corresponds to the subject (*the boy*), while the patient role to the object (*the dog*) (2b).

(1) Syntactic structure

a. [NP_1 – verb (*hits*) – NP_2]	phrases
b. [subject – verb (*hits*) – object]	functions

(2) Semantic structure

a. [hitter – verb (*hits*) – hittee]	semantics
b. [agent – verb (*hits*) – patient]	thematic structure

Based on the traditional linguistic account described above, argument structure involves syntactic as well as semantic relations: while the NPs in (1a) are in a syntactic relation with respect to their functional roles as the subject and the object (1b), at the same time these constituents correspond to distinct semantic (2a) and thematic roles (2b), forming thematic relations derived from conceptual/semantic functions that express the meanings of verbs. The procedure of linking the syntactic roles of constituents to the conceptual information they carry is referred to as *syntax-semantics mapping* (for a review on different mapping/linking theories, see Butt, 2006, pp. 91–149). For the sake of completeness, there are also theoretical accounts of argument structure that do not distinguish between syntactic and semantic representations and thus avoid mapping altogether (e.g., Borer, 2005; Marantz, 1997; see also Pylkkänen, 2008, for an alternative approach to argument structure).

What do we know when we know a verb in a certain language? Do we know the verb's word category, its conceptual content as well as the detailed syntactic information restricting the environment in which it can appear? Traditional linguistic approaches to argument structure (e.g., Chomsky, 1981; Jackendoff, 1972; Levin & Rappaport, 1986; Williams, 1981) incline towards a *lexicalist view* according to which the detailed argument structure information including syntactic and conceptual/thematic specifications of arguments are stored in the lexical entries of verbs. These lexical entries are listed in our mental lexicon, defined as "the repository of information about words" (Levin, 1991, p. 205). The non-lexicalist approaches hold the opposing view that verb roots include only conceptual information but no syntactic information, which is either derived from the syntactic context they appear in (e.g., Borer, 2005; 2003) or from merging with their category-defining functional heads (e.g., Embick & Noyer, 2007; Marantz, 1997). According to these approaches, verb meaning is determined compositionally, not lexically. Finally, Ramchand (2008) presents a synthesis of the lexicalist and the non-lexicalist position, suggesting that only minimal information restricting the syntactic position of a lexical item is included in lexical entries, while detailed thematic specifications are not (for a review, see Lohndal, 2020). To sum up, the general consensus is that lexical entries of verbs encode certain information relevant to their integration in the language structure although linguistic theories are in a debate on the exact content of this information.

1.2.1. Classification of verbs

Verbs can be grouped with respect to the syntactic environments in which they appear as well as based on the different types of syntactic and thematic relations they encode. Two types of classifications central to the topic of the present thesis are summarized in this section: the first type of classification defines verbs with respect to the number of arguments that are involved in the event described by the verb (Section 1.2.1.1.); the second type categorizes verbs based on the manner in which their syntactic arguments map onto their thematic roles (Section 1.2.1.2.).

1.2.1.1. The number of arguments

Intransitive verbs such as *jump, run* or *laugh* require only one syntactic argument: a subject (3). Transitive verbs, such as *chase*, *kiss* or *hit* require two syntactic arguments: a subject and an object (4). Finally, ditransitive verbs, such as *give*, *receive* or *put*, require three syntactic arguments: a subject, a direct object and an indirect object (5).

(3) The boy $_{\text{SUBJ}}$ *jumps.* (one-argument verb)

(4) The boy $_{\text{SUBJ}}$ *chases* the girl. $_{\text{OBJ}}$ (two-argument verb)

(5) The boy $_{\text{SUBJ}}$ *gave* a book $_{\text{DO}}$ to his friend. $_{\text{IO}}$ (three-argument verb)

While some verbs can optionally select a different number of arguments, others only allow one configuration option. For example, the verb *eat* is optionally transitive because it can stand either with or without an object (6), while the verb *like* is obligatorily transitive as it typically cannot stand without an object (7).

(6) The $_{\text{SUBJ}}$ boy *eats*. $_{(\emptyset)}$ (optional transitivity)
The boy $_{\text{SUBJ}}$ *eats* his snack. $_{\text{OBJ}}$

(7) *The boy $_{\text{SUBJ}}$ *likes*. $_{(\emptyset)}$ (obligatory transitivity)

The boy $_{\text{SUBJ}}$ *likes* his snack. $_{\text{OBJ}}$

1.2.1.2. The canonicity of argument mapping

Another distinction can be drawn between two sub-classes of intransitive verbs, first described by Perlmutter (1978) and later analyzed across a variety of theoretical frameworks, known as the *Unaccusative Hypothesis*. This hypothesis proposes that intransitive verbs can be divided into two sub-classes, i.e., unaccusatives and unergatives, each with distinct syntactic configurations and semantic/thematic properties. These two subgroups also differ in the way they map their thematic roles to the subject position. While unergatives like *jump* (10) assign their subject the thematic role of an agent (i.e., initiating the action), the unaccusatives like *fall* (11) select a theme/a patient role (which is not represented as the initiator of the event) as their subject. In the vast majority of syntactic environments the subject position typically corresponds to an event initiator. Hence, unergatives can be described as undergoing *canonical argument mapping* and unaccusatives, which assign a theme/a patient role to their subject, can be analyzed as undergoing *non-canonical argument mapping*.

(10) The boy $_{\text{agent}}$ *jumped.* (canonical mapping)

(11) The boy $_{\text{patient}}$ *fell*. (non-canonical mapping)

One additional phenomenon related to unaccusatives is the *causative alternation* (Levin & Rappaport Hovav, 1995, pp. 79–133). While some unaccusative verbs like *break* allow two distinct argument realizations (12), i.e., a non-causative (12a) and a causative variant (12b), other unaccusative verbs like *fall* do not allow the same alternation (13) and only select a non-causative option (13a and 13b). Hence, verbs like *break* can be classified in more than one subcategory and can be analyzed as unaccusative or transitive depending on the syntactic context in which they appear.

(12) a. The vase $_{patient}$ *broke.* (alternating)

b. The boy $_{agent}$ *broke* the vase. $_{patient}$

(13) a. The vase $_{patient}$ *fell*. (non-alternating)

b. *The boy $_{agent}$ *fell* the vase. $_{patient}$

Distinct linguistic theories explain the behavior of unaccusatives in different terms. Some theories assume that unaccusative sole arguments undergo a movement from the object to the subject position (Burzio, 1986). Others explain the unaccusative behavior purely in terms of their semantic/aspectual properties (Dowty, 1991; Leiber & Baayen, 1997; van Valin, 1990), with respect to their thematic properties (Belletti & Rizzi, 1988), or provide an intermediate view in which the sole argument of unaccusatives is semantically determined but syntactically represented (Levin & Rappaport Hovav, 1995; Perlmutter, 1978; Sorace, 2000). However, what all these approaches agree on is that unergatives and unaccusatives differ in the way they represent the particular event: while the unergative argument expresses event initiation, the unaccusative argument does not.

Although the unaccusative/unergative distinction (as well as causative alternation) is pervasive across languages, the verb classification into one or the other category varies from language to language, i.e., the translational equivalent of a verb classified as unergative in one language can fall into the unaccusative category in another language. This is arguably due to distinct cross-linguistic argument structure realization patterns and due to fine-grained aspectual differences between verbs across languages (for distinct cross-linguistic comparisons, see Folli & Harley, 2008; Rappaport Hovav & Levin, 2000; Rosen, 1984; Sorace, 2000; Zaenen, 1993).

Various semantic/aspectual (e.g., Rappaport Hovav & Levin, 2000; Sorace, 2000), syntactic (e.g., Burzio, 1986; Rosen 1984), or mixed (e.g., Legendre et al., 1991) diagnostic approaches to classify unaccusatives/unergative verbs have been proposed to date but no single, unifying rule that would reliably distinguish unaccusatives from unergatives has been suggested. Consequently, different diagnostics are often combined and these vary across languages. For example, many Western European languages including German (Keller & Sorace, 2003), Dutch (Lieber & Baayen, 1997), Italian (Sorace, 2000), French (Legendre & Sorace, 2003), and Basque (Laka, 1996) differentiate unergatives and unaccusatives by means of auxiliary selection. Typically, unergative verbs select the auxiliary *have*, while unaccusative verbs select the auxiliary *be.* However, notable variability has been described both within and across languages (Sorace, 2000), indicating that auxiliaries correlate with, rather than reliably split, the two sub-classes.

1.2.2. The role of morphological case

Ever since Fillmore (1968) proposed an explicit connection between case marking and verb argument structure, grammatical case has been one of the central foci in the study of argument structure relations. So far we have been describing the basic terms and principles of argument structure utilizing examples in English. However, morphological case is one of the linguistic phenomena that are very scarce or non-existent in the English language. While English realizes arguments mainly structurally (i.e., through their syntactic positions), other languages employ distinct means in the form of case systems that morpho-syntactically mark roles of different arguments in the sentence (Williams, 1981, p. 82). Within these languages, morphological case constitutes a handy tool for marking relationships between verbs and arguments (Butt, 2006, p. 4). Distinct languages employ different case systems which can be described with respect to the morpho-syntactic argument alignment, i.e., with what case agents and themes/patients are marked. Two distinct case alignment systems will be briefly described here: 1) nominative-accusative and 2) ergative-absolutive.

Slavic languages are typical representatives of nominative-accusative alignment. To illustrate the alignment in a concrete Slavic language, Czech utilizes an accusative case marking (morphemes -*u or* -*i*) for those NPs (feminine gender, 3rd person sing.) that stand as direct objects of verbs, while the NP that holds the subject position is assigned a nominative case and stays unmarked (Ø) (14). Note that although English or Spanish also use a nominative-accusative case alignment system like Slavic languages, it is overtly expressed only by pronouns (e.g., English: *me*, *her*, *him*; Spanish: *me*, *te, le*) but no case morphology is present (14, 15, 16).

(14)	Chlapec (Ø) $_{\text{NOM}}$	volal	dívk-**u**. $_{\text{ACC}}$
	A boy (Ø)	*called*	*a girl* (Ø). $_{\text{ACC}}$

(15)	A boy (Ø) $_{\text{NOM}}$	called	**her**. $_{\text{ACC}}$

(16)	Un niño (Ø) $_{\text{NOM}}$	**me** $_{\text{ACC}}$	llamó.
	A boy	me	called.
	A boy called me.		

Unlike Czech, English, or Spanish, Basque adopts an ergative-absolutive case alignment system. What Basque and Czech have in common is that they both mark their subjects/agents and objects/patients by the means of inflectional case morphology. However, their case alignment systems differ: in contrast to nominative-accusative languages, which assign nominative case to subjects/agents and accusative case to patients/direct objects, Basque marks subjects/agents with the ergative case (a morpheme -*k*), while the direct object/patient in absolutive case stays unmarked (17) (Laka, 1996; Laka, 2006; Levin, 1983).

(17) Mutila-**k** $_{\text{ERG}}$ neska-Ø $_{\text{ABS}}$ besarkatu du.
The boy the girl hug has.
The boy has hugged the girl

To sum up, while Slavic languages utilize a morphological case (i.e., accusative) that marks patients/themes with a specific inflectional morpheme, Basque employs a different morphological case (i.e., ergative) that assigns a specific inflectional morpheme to agents. As a consequence, Basque single arguments of unergative verbs are assigned ergative case marked with -*k* morpheme (18a), while arguments of unaccusatives verbs are assigned absolutive case and stay unmarked (18b) (Cheng & Demirdache, 1993, p. 72).

(18) a. Neska-**k** $_{\text{ERG}}$ dantzatu du. (unergative sentence)
The girl dance has
The girl has danced.

b. Neska-Ø $_{\text{ABS}}$ erori da. (unaccusatives sentence)
The girl fall is.
The girl has fallen.

Note that there is no such morphological distinction among unergatives/unaccusatives in nominative-accusative case alignment systems as those often mark their patients/themes but not agents. As Butt (2006) pointed out, languages derived from Latin and Greek use the same case marking for both agentive and non-agentive subjects, which stands in direct contrast to languages like Basque with distinct inflectional marking for these two subject types (p. 154).

Ramchand (2013) has argued that "(…) there are a number of reasons to include case marking patterns in the empirical ground that forms the basis of our understanding of argument structure." For example, as she put it: "(…) there are many cases of case-marking patterns which have a reliable correlation with semantics" (p. 306). She further emphasized that it is important to consider grammatical case as a possible candidate for inclusion into what we understand as argument structure. In line with this argumentation, the present thesis will consider morphological case marking patterns as an inseparable part of argument structure relations.

1.3. Verb argument structure: A psycholinguistic account

In Section 1.2., argument structure was described from a linguistic viewpoint which focused on language structure (i.e., the system of linguistic units and their relations). This section aims to describe verb argument structure from a psycholinguistic perspective, focusing on how we process argument structure and the information it contains. Nevertheless, as Jackendoff (1983) pointed out, in spite of this distinction, linguistics and psycholinguistics have a mutual influence: "On the one hand, a theory of language processing presupposes a theory of linguistic structure; on the other hand, one crucial test of a theory of linguistic structure is whether it can be integrated into a theory of processing"

(p. 5). The general idea behind bringing together linguistic and psycholinguistic inquiries is, as Ramchand (2014) put it, "(...) to build cumulative databases of correlations between linguistic representations and processing behavior across different tasks that will allow us to make progress on the deepest issues of symbolic thought" (p. 186).

Psycholinguistic models are not primarily occupied with how the argument structure information is represented or how it is associated with verbs in our mental lexicon. Instead, they focus on how we use this information during language processing to derive the argument relations that verbs encode (Friederici & Frisch, 2000). Within psycholinguistic models, various cognitive operations (e.g., access, retrieval, encoding) are postulated to explain how distinct linguistic units are computed in real time during speech production or comprehension (Gambi & Pickering, 2017; Jackendoff, 1983).

1.3.1. Cognitive architecture of argument structure production

The ultimate purpose of a cognitive model of speech production is to explain how we map our communicative intentions into fluent speech (Levelt, 1999a, p. 89). The classical production models can be roughly divided into serial (e.g., Bock & Levelt, 1994; Levelt et al., 1999) and interactive accounts (e.g., Chang et al., 2006; Dell & Sullivan, 2004; Stemberger, 1985). What serial and interactive models mostly disagree on are the details of the organization and interaction among components of the model architecture (Levelt, 1999a, p. 89). While serial models view language production as a staged process, where later stages do not influence the previous ones, interactive models incorporate feedback among different processing stages. Nevertheless, as Levelt (1999a) pointed out, these disagreements do not "(...) affect the consensus on the general architecture of the system" (p. 89) and an agreement has been reached on the major building blocks of the functional architecture of speaking (Ferreira & Slevc, 2007; Levelt, 1999b; Slevc, 2023; Thompson et al., 2015). The major components include: 1) message encoding, 2) grammatical encoding, 3) phonological and phonetic encoding, and 4) articulation (Figure 2). The rest of this subsection briefly describes the grammatical encoding component of the consensus model (Bock & Levelt; 1994; Bock, 1995; Ferreira & Slevc, 2007; Slevc, 2023), which is the phase that ensures argument structure information is accessed, retrieved, and integrated to achieve the end product of speech production.

First, the preceding component of message encoding provides its input in the form of a conceptualized preverbal message, i.e., concepts expressible in a language. Once this non-linguistic message is constructed, grammatical encoding processes this input in two separate stages: 1) the *functional processing* stage (referred to as Selection in Figure 2), which involves selecting linguistic units and accessing their linguistic properties; and 2) the *positional processing* stage (referred to as Retrieval in Figure 2), which accomplishes the retrieval of the concrete word forms and assigns their sentence positions.

The functional processing stage entails activation of abstract representations called *lemmas* which correspond to the concepts previously defined within the message encoding component. Lemmas are modality-neutral representations (e.g., the same for speaking or writing) stored in the mental lexicon and defined with respect to their syntactic properties, which become available once a specific lemma is selected (for details on lexical access and selection, see Roelofs, 1992; see also Levelt, 2001). If, for example, the verb *select* is utilized to express an intended message, its required arguments and thematic roles are also accessed (Figure 3). The verb *select* encodes transitive properties, i.e., it incorporates a subject NP and an object NP. It also specifies how these NPs correspond to their thematic roles (actor/agent and theme/patient) and lists other grammatical features such as tense, aspect, case, number or person used to build a rudimentary sentence structure (Levelt, 1999a, pp. 88–96).

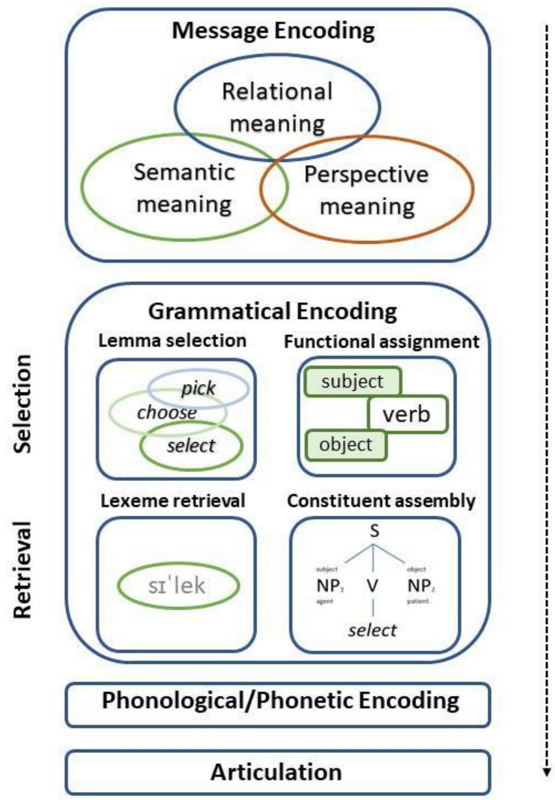


Figure 2. The main components of the language production system (adapted from Bock & Levelt, 1994 and Slevc, 2023).

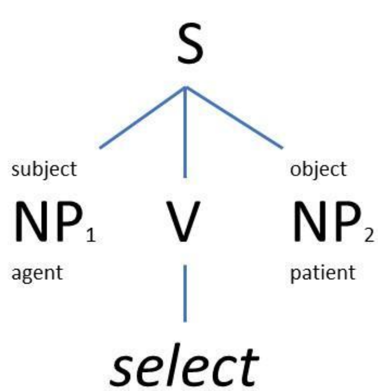


Figure 3. The syntax of the lemma for the verb *select* (adapted from Levelt, 1999a, p. 94).

Once the lemma has been chosen and its syntactic and thematic configuration is activated, the positional processing stage can take place. The argument structure information accessed during functional processing guides the allocation of linear positions in the sentence with an underlying hierarchical syntactic structure and navigates the inflectional assignment. Each sentence constituent is positioned in a grammatically sound syntactic structure consisting of an ordered set of whole-word, inflected, and modality specific constituents termed *lexemes* (Figure 4). Note that in Figure 4 the accusative pronoun *him*, not a nominative *he*, is retrieved for the final structure. As Levelt explains,

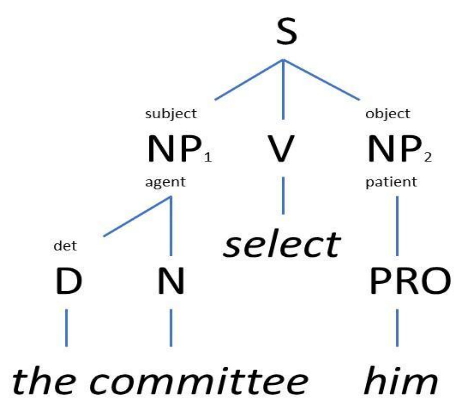


Figure 4. The final syntactic structure built with the verb *select* (adapted from Levelt, 1999a, p. 98).

when a constituent unites with an assigned NP, it inherits the case assignment from the verb (Levelt, 1999a, p. 99). Hence, the model architecture, in line with the linguistic accounts presented in Section 1.2., considers case information as an inherent part of argument structure information.

Once grammatical encoding is completed, phonological encoding is initiated and grants access to the phonological properties of concrete word-forms, triggering an articulatory gesture for each word and its phonetic realization. This leads to the end-product of overt speech (Levelt, 1999a, p. 88).

One important assumption of the model is the incrementality of processing, i.e., speakers can start producing individual constituents before the whole sentence structure is fully retrieved. Another key assumption—the hierarchical nature of syntactic relations (as illustrated in Figure 4)—presumes that individual sentence items are constrained by their hierarchical links rather than the linear order in which they appear. For example, subjects can be planned and retrieved earlier than verbs; however, planning direct objects follows planning verbs no matter the sentence position in which the direct object linearly appears. Finally, as Levelt pointed out:

> (...) languages differ in how they encode syntactic relations. Some languages, such as English, prefer to encode them in terms of phrasal relations and order relations within a sentence. Other languages prefer to mark lemmas in the surface structure for their syntactic function. (Levelt, 1999a, p. 94)

Nevertheless, in Levelt's view, no matter how a particular language encodes this information, the general architecture of the model should hold cross-linguistically.

There have been disagreements on some of the details of the grammatical encoding component. One of the disputes evolved around the lemma selection and whether or not it needs to be selected before the lexeme is assessed. Alternative suggestions (e.g., Dell & Sullivan, 2004) advocated the interactive approach, which allowed that feedback from lexemes could influence lemma selection. Finally, a one-stage solution motivated by speech errors committed by PWA has also been suggested (e.g., Caramazza, 1997). However, as Ferreira and Slevc assert, none of these minor disagreements undermine the fundamental character of the consensus production model (Ferreira & Slevc, 2007, p. 458), which has been successfully used for the past few decades to guide speech production research across various subfields of psycholinguistics, from language acquisition through multilingual speech processing to aphasiology (Slevc, 2023, p. 21).

1.3.2. Cognitive architecture of argument structure comprehension

The goal of language comprehension is to create an interpretation of an utterance. This process consists of converting speech input into a representation of meaning guided by a native speaker's knowledge of his/her language. As for the current comprehension models, we have not yet arrived at the same consensus model parallel to that postulated for speech production. In general, however, existing comprehension models postulate approximately the same processing components as models of production, only in a reversed order (Figure 5): 1) acoustic, phonetic, and phonological decoding; 2) access to lexical-semantic information; 3) decoding and integration of argument structure information; and 4) message interpretation (Bornkessel & Schlesewsky, 2006; Cutler & Clifton, 1999; Friederici, 2002; 2011). The level of detail needed to successfully interpret argument structure may nevertheless differ from what we have described within the production domain. As Bock pointed out:

> There can be no argument about whether syntax is 'important' in production, because the speaker as a matter of course creates those features of utterances that we call their syntax [and while it is clear that certain features of argument structure are utilized in comprehension] it is considerably less clear whether language

comprehension requires that listeners reconstruct these features to the same level of detail [as required for production]. (Bock, 1995, p. 205)

Empirical evidence from distinct behavioral paradigms has given rise to two traditional classes of comprehension models: serial, syntax-first models (e.g., Frazier, 1987; Frazier & Fodor, 1978) and interactive, constraint-satisfaction models (e.g., Marslen-Wilson & Tyler, 1980; McClelland & Kawamoto, 1986). What these two classes of model mostly disagree on is what type of information becomes available when (i.e., when the integration of semantic and syntactic information from the input takes place). Nevertheless, current neurocognitive models of language comprehension, which also rely on data obtained from techniques with high temporal resolution such as EEG (Bornkessel & Schlesewsky, 2006; Friederici, 2002; 2011; Schlesewsky & Bornkessel, 2004), agree that once the acoustic and phonological segmentation is achieved, sentence comprehension takes place in three subsequent stages: 1) an initial parsing phase based on word category information; 2) the establishment of syntactic and thematic relations; and 3) an integration (with possible revision) phase (Figure 5).

In the first phase, an initial structure is built on the basis of the word category of each sentence constituent. This initial structure building is independent of semantic and verb argument information and no relational interpretation is taking place yet. It is during the second phase when the relation between the verb and its arguments is computed.

The second phase is responsible for decoding who is doing what to whom. Here, any semantic (e.g., animacy) and syntactic features (e.g., case marking) are processed and the syntactic and thematic relations are established.

During the third phase, semantic and syntactic information is integrated to achieve the final interpretation of the utterance. At this point, information from discourse and world knowledge is taken into account and mapped onto the established relations. If the integration and subsequent interpretation fail, a repair process is initiated and relations are re-analyzed.

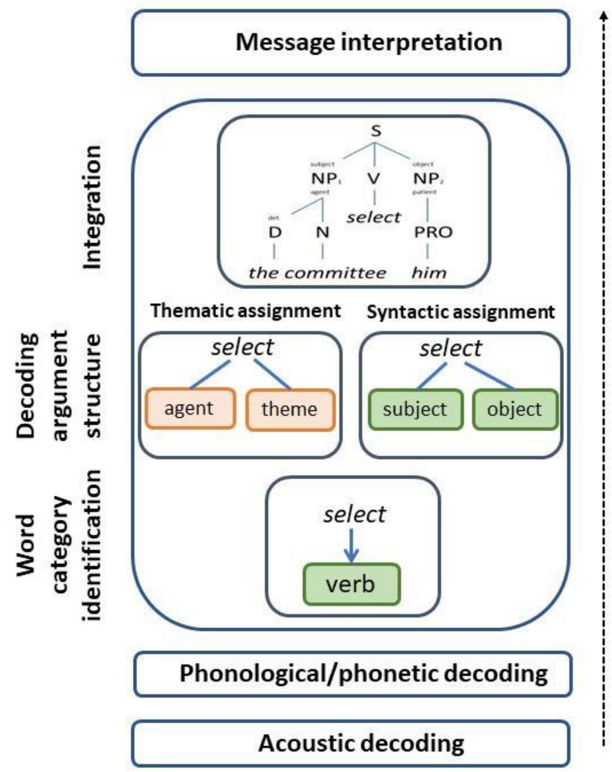


Figure 5. The main components of the language comprehension system (adapted from Bornkessel-Schlesewsky & Schlesewsky, 2008; Friederici & Levelt, 1988).

Although the current cognitive models of comprehension attempt to provide an inventory of different types of argument structure information fundamental to sentence comprehension at each processing phase, the detail of this information has not been developed to the same level as in the production domain. What has, however, been established is that language-specific features, such as case morphology or base word order, can further modulate the comprehension process and differentially impact the processing strategies, as shown by previous cross-linguistic research (e.g., Bates et al., 2001; Bornkessel-Schlesewsky & Schlesewsky, 2009). Therefore, models of language processing have to account for the fact that various types of grammatical information (e.g., case morphology) become available at different times or to different degrees depending on the language in use. The same types of linguistic information may not be equally relevant for comprehension processes across distinct languages (Bornkessel-Schlesewsky & Schlesewsky, 2009) and cross-linguistic variations can lead to the varying use of the basic mechanisms underlying speech processes (e.g., encoding, retrieval, working memory or planning) and differentially tax the cognitive system (Bates et al., 2001, p. 371). If cognitive models aim to adequately describe the general language processing mechanisms, they also need to identify and adapt to relevant cross-linguistic modulations (Bornkessel & Schlesewsky, 2006; Bornkessel-Schlesewsky & Schlesewsky, 2009).

1.4. Psycho- and neuro-linguistic correlates of argument complexity

This section reviews empirical evidence from experiments that measure behavioral and neural responses to argument structure complexity manipulations. The aim of this review is to introduce and summarize evidence in favor of the phenomenon of argument structure complexity effects which has been well documented in both neurotypical populations and speakers with aphasia across several domains, tasks, and languages.

It has long been established across distinct subfields of cognitive psychology that the complexity of various aspects of an input affects the way in which we receive and process it. For example, within the visual perception domain, visual complexity (e.g., the level of detail contained within an image) negatively influences the rate at which an image is processed (e.g., Leckart & Bakan, 1965; Snodgrass & Vanderwart, 1980). In other words, it takes longer to recognize, retrieve, and subsequently name objects or actions depicted by more visually complex pictures. The same is true for processing linguistic structures in the language domain: various factors of argument structure complexity, such as the number of arguments or the canonicity of argument mapping, have been reported to affect language processing both behaviorally and neurophysiologically. This effect gives rise to the phenomenon we refer to as *argument structure complexity effects* (for a review, see Ramchand, 2014; Thompson & Meltzer-Asscher, 2014).

At the behavioral level, increasing argument structure complexity can be reflected as a rise in *processing cost* defined as the amount of cognitive resources (e.g., memory or attention) used to process a stimulus. The processing cost can be measured via reaction times (RTs: the more cognitively demanding, the slower the process), error rates (the more cognitively demanding, the higher error rate), or planning strategies (the more cognitively demanding, the longer the planning as reflected via speech onset times (SOTs) or eye-fixation durations). Nevertheless, argument structure complexity is not the only factor influencing the processing cost of verbal stimuli. In fact, numerous psycholinguistic factors, such as word frequency or length, need to be carefully controlled and held constant when the complexity of any type of verbal stimulus is being measured.

At the neuropsychological level, argument structure complexity effects have been traditionally studied via performance in production and comprehension tasks in PWA where distinct neuro-pathologies can lead to difficulties associated with verbs and sentences with more complex argument structure. More recently, increased neural activation correlated with increasing argument structure complexity has been studied with the use of event-related potentials (ERPs) or neuroimaging techniques (e.g., fMRI) (Thompson & Meltzer-Asscher, 2014).

A question that brings us back to the linguistic theories of argument structure arises as to whether higher processing cost measured via the above mentioned methods necessarily entails higher linguistic complexity. In other words, are the types of argument structure that are more costly for processing also linguistically more complex? As Ramchand (2014) pointed out, the processing difficulty associated with a specific type of verb argument structure does not necessarily need to entail higher linguistic complexity. Indeed, not all the manifestations of increased processing cost derive from linguistic complexity, even though linguistic manipulations have been demonstrated to contribute to higher processing loads (e.g., Laka & Erdocia, 2012; Thompson & Meltzer-Asscher, 2014). In Ramchand's view, one should also keep in mind that when assessing processing cost in language impaired populations, what is more costly to process for PWA might not increase the processing load in neurotypical individuals (Ramchand, 2014, p. 191). Nevertheless, as she adds:

> (...) correlations are valuable even in the absence of the complete knowledge that we would require to interpret the correlations in an absolute sense. Building up a reliable picture depends crucially on linguists, psycholinguists and neurolinguists using the same basic granularity of variables to be tested, replicating and building on each other's results to establish new correlational generalizations. (Ramchand, 2014, p. 197)

The following sections review empirical evidence from experiments that contrast selected levels of argument structure complexity relevant for the present thesis (the number of arguments (Section 1.4.1.) and the canonicity of their mapping (Section 1.4.2.)) and that measure behavioral and neural correlates of this contrast. The final section introduces empirical evidence to support the idea that morphological case marking may also contribute to the modulation of argument structure processing cost (Section 1.4.3.).

1.4.1. Contrasting the number of arguments

Past studies investigating the processing of isolated verbs with varying numbers of arguments in neurotypical speakers have reported longer SOTs for verbs that require more arguments in Italian (Barbieri et al., 2019), German (e.g., Kauschke & von Frankenberg, 2008), and English (Malyutina & den Ouden, 2015) during picture naming. Transitive verbs have also been reported to elicit longer RTs than intransitive verbs in a lexical decision task in German (Kauschke & Stenneken, 2008). Importantly, the argument structure complexity effects found at the single-word level support lexicalist models of speech production, which assume that argument structure information is encoded in a verb's lexical entry (e.g., Bock & Levelt 1994; Levelt et al., 1999). If the argument structure information was to be accessed during the later stages of grammatical encoding or constructed based on contextual factors, argument structure complexity effects for isolated verbs would not be expected.

Moving beyond the single-word level, similar effects have also been observed in sentence context. For example, ditransitive and transitive sentences elicited significantly longer SOTs than intransitive ones during argument structure production in Italian (Barbieri et al., 2019). Furthermore, results of experiments using the cross-modal lexical decision paradigm demonstrated verbs with more arguments elicited slower responses and integration times compared to verbs with fewer arguments in English (Ahrens, 2003;

Ahrens & Swinney, 1995). Malyutina and den Ouden (2017) also reported faster RTs when performing grammaticality judgment in intransitive sentences when compared to transitive ones in English.

Several experiments in English using neuroimaging methods found increased brain activation in response to isolated transitive verbs compared to intransitive verbs in picture naming (den Ouden et al., 2009) or lexical decision tasks (Malyutina & den Ouden, 2017; Meltzer-Asscher et al., 2015). Similarly, in the sentence context, verbs with more arguments were reported to increase brain activation compared to intransitive verbs during a grammaticality judgment task in Hebrew (Ben-Shachar et al., 2003).

With respect to language-impaired populations, various studies have observed that English-speaking individuals with aphasia used intransitive verbs more often than transitive verbs, and those were used more often than ditransitive verbs in connected speech (Kim & Thompson, 2004; Malyutina et al., 2016; Thompson, 2003; Thompson et al.,1995). Furthermore, increased processing difficulty associated with verbs requiring more arguments has been found in picture naming in English (Caley et al., 2017; Cho-Reyes & Thompson, 2012; Kim & Thompson, 2000; 2004; Thompson et al., 1997; 2012), German (de Bleser & Kauschke, 2003), Italian (Luzzatti et al., 2002), and Korean (Sung, 2016). The same findings were also reported in picture-based story completion in English (Thompson et al., 1997) or during sentence production in Russian (Dragoy & Bastiaanse, 2010), Basque (Pourquié, 2013), and English (Cho-Reyes & Thompson, 2012; den Ouden et al., 2019; Thompson et al., 1997).

In sum, these studies show that a higher number of arguments can lead to higher processing costs across both production and comprehension in neurotypical speakers as reflected by higher error rates, RTs, or SOTs or by increased brain activation in tasks targeting single-word, sentence, or discourse levels of language representation. Additionally, the effect of the number of arguments manifests itself in PWA, typically in the form of an increase in error rates and/or a decrease in the overall production of verbs that require more arguments.

1.4.2. Contrasting the canonicity of argument mapping

Behavioral studies in neurotypical English-speaking populations contrasting unaccusatives (verbs like *fall* with non-canonical argument mapping) and unergatives (verbs like *run* with canonical argument mapping) have observed higher error rates for unaccusatives in picture naming (McAllister et al., 2009) and slower RTs for unaccusatives in lexical decision tasks (Meltzer-Asscher et al., 2015). In the sentence context, increased processing costs (i.e., slower RTs or SOTs) have been reported for unaccusatives compared to unergatives in a probe recognition task in Spanish (Bever & Sanz, 1997) or in a picture-word interference task in English (Momma et al., 2018).

Various studies with neurotypical speakers using neuroimaging techniques that contrasted unergative and unaccusative verbs also reported increased brain activation in response to unaccusatives while performing a lexical decision task in English (Meltzer-Asscher et al., 2015). Additionally, similar effects were observed during sentence comprehension in Hebrew (Shetreet et al., 2010; Shetreet & Friedmann, 2012).

Finally, numerous studies have shown that unaccusatives are more difficult to produce for English speaking PWA when compared to unergatives in a picture naming task (McAllister et al., 2009), during a sentence elicitation task using visual probes (Lee & Thompson, 2004), in a constrained production task (Thompson, 2003) or in connected speech (Kegl, 1995). Findings from Italian (Luzzatti et al., 2002), Dutch (Bastiaanse & van Zonneveld, 2005), Korean (Sung, 2016), and Spanish (Martínez-Ferreiro et al., 2014; Sanchez-Alonso et al., 2011) support the view that verbs with non-canonical thematic mapping present more difficulties for PWA at both single-word and sentence level across a variety of languages.

To sum up the evidence presented in this section, when unaccusatives and unergatives are contrasted, unaccusatives often show increased error rates, slower RTs and increased brain activation in neurotypical speakers in addition to more difficulties observed during production for PWA. These argument complexity effects have been documented across various tasks and languages and are generally explained as resulting from the non-canonical argument mapping that unaccusatives undergo.

1.4.3. Building a case for morphological case

Previous cross-linguistic research in Basque—a language with an ergative-absolutive case alignment system (Section 1.2.2.)—has demonstrated that ergative case processing might diverge from what was previously described in languages with a nominative-accusative case alignment system. This section reviews relevant studies that explore distinct processing correlates of the ergative case in Basque, establishing the grounds for the inclusion of ergative case morphology as a possible contributor to argument structure complexity effects.

Carreiras and colleagues (2010) tested Basque speakers in the comprehension of subject relative vs. object relative sentences with the use of self-paced reading and ERPs. In contrast to subject relatives, object relatives have been reported to be more difficult to process in neurotypical adults (e.g., Traxler et al., 2002), PWA (e.g., Berndt et al., 1997b; Friedmann, 2008; among others), and to be acquired later during first language acquisition (e.g., Belletti & Contemori, 2010; Costa et al., 2011; Friedmann & Novgorodsky, 2004) across various nominative-accusative languages. Importantly, in Basque, the subject NP of subject relatives is marked with the ergative case, while the object NP of object relatives is assigned the absolutive case and stays unmarked. In their study, Carreiras and colleagues observed that, in Basque, where ergative-absolutive case marking differentiates between the two types of relative clauses, the object relatives are processed faster, which is in contrast to evidence from nominative-accusative languages. In line with these findings, Munarriz and colleagues (2016) tested a bilingual Basque-Spanish participant with Broca's aphasia who had higher accuracy in object relatives as compared to subject relatives in Basque, while the opposite trend was observed in his performance in Spanish. Finally, Gutiérrez-Mangado (2011) tested object and subject relatives in Basque-speaking four-year-old and six-year-old children and adults using a sentence-picture matching task. Again, higher accuracy was reported for object relatives compared to subject relatives across tested groups. Together, these studies support the notion that sentences marked with the ergative case incur a higher processing cost.

Further evidence for the higher processing cost associated with ergative sentences comes from a recent experiment conducted by Martinez de la Hidalga and colleagues (2019). In their study, they contrasted unergative and unaccusative sentences with number and case violations in a grammaticality judgment task. In the grammatical condition, they found slower RTs for unergative compared to unaccusative sentences. Again, this finding goes against evidence from languages with nominative-accusative case alignment and indicates that unergatives may be more costly to process than unaccusatives in Basque, possibly due to the ergative case morphology.

Finally, Arantzeta et al. (2019) studied the comprehension of monolingual Spanish and bilingual Basque-Spanish PWA matched with neurotypical controls listening to sentences in agent-theme vs. theme-agent order. As discussed in Section 1.2.2., the ergative and absolutive case are assigned to agents and themes (respectively) in Basque and need to be processed to achieve accurate sentence interpretation. Arantzeta and colleagues found higher error rates in Basque compared to Spanish in both sentence conditions for PWA and also in the theme-agent condition for neurotypical speakers. Their results imply that the Basque-specific case morphology, which needs to be processed to achieve accurate sentence interpretation, might modulate the performance during sentence comprehension.

To sum up, the reviewed studies from Basque suggest that its ergative case marking modulates the processing costs of arguments, diverging from argument complexity effects typically expected in traditionally studied, nominative-accusative languages. Moreover, the studies targeting PWA (Aranzteta et al., 2019; Munarriz et al., 2016) further imply that the ergative case marking might also be prone to processing disruptions and impairment in Basque-speaking PWA.

1.5. The present thesis

The Section 1.2.2. addressed how distinct languages differ in marking their arguments with case morphology. The reviewed cross-linguistic evidence in Section 1.4.3. suggests that contrasting case marking in ergative-absolutive languages may lead to behavioral correlates different from those observed in languages with nominative-accusative case alignment. These correlates have been presented alongside correlates of the argument number and the argument mapping manipulations in both neurotypical and language impaired populations (Section 1.4.). The overarching goal of this thesis is to explore the contribution of ergative case marking as an additional factor modulating the argument structure complexity effects alongside the number of arguments and the canonicity of argument mapping previously studied in nominative-accusative languages.

1.5.1. Rationale

Basque is a unique example of a language with theoretically interesting morpho-syntactic properties related to ergative case morphology. Assuming verb-specific morpho-syntactic requirements, including case morphology, are part of the argument structure information (in line with lexicalist approaches to argument structure; Section 1.2.), the ergative case marking could be expected to increase the processing cost of lexical entries within those Basque verbs (i.e., unergatives and transitives) that dictate an ergative case assignment. In other words, when contrasting verbs that assign an overt subject case marking with verbs that do not, one might expect similar argument structure complexity effects to occur as those resulting from manipulating the number of arguments or canonicity of argument mapping. If this is so, the assignment of the ergative case would be expected to influence the processing cost of Basque verbs differentially when contrasted with languages that undergo nominative-accusative case alignment and do not mark their arguments in the same fashion (e.g., Spanish or English).

1.5.2. Objectives

The first objective of this thesis is to assess *if* and *how the ergative-absolutive case marking contributes to processing costs of selected verb groups (unergatives, unaccusatives, and transitives) in a Basque-speaking neurotypical population*. To reach this objective, the processing cost associated with these verb groups will be assessed alongside the processing patterns elicited by the same verb groups in Spanish, a language that is expected to follow argument structure complexity effects observed in other, previously studied languages with nominative-accusative case alignment (Sections 1.4.1. and 1.4.2.). The complexity dimensions contrasted within these verb groups include: 1) the number of arguments, 2) the canonicity of argument mapping, and 3) the ergative-absolutive case assignment (in Basque). The selected verb groups are tested in both Basque and Spanish using a within-subject design, i.e., in Basque-Spanish simultaneous bilinguals. Such design allows us to control for within-subject variability, facilitating the cross-linguistic comparison.

The second objective is to assess *if* and *how ergative-absolutive case marking contributes to processing difficulties in Basque-speaking PWA*. To reach this objective, the processing difficulties associated with the same verb groups (i.e., unergatives, unaccusatives, and transitives) are assessed for both languages of a Basque-Spanish bilingual PWA alongside a Spanish-English bilingual PWA with similar language impairment symptoms. The evaluation of processing difficulty patterns across languages with different case alignment systems is expected to inform us about processing difficulties uniquely associated with ergative case markings.

1.5.3. Argument structure properties of studied languages

Before we examine the concrete hypotheses and predictions tested in this thesis, a brief review of selected linguistic properties of Basque, Spanish, and English—the three languages that constitute our cross-linguistic inquiry—are provided to set the grounds for our predictions.

Basque is a language isolate spoken in the Basque country, located mostly on the Iberian Peninsula and extending to both French and Spanish territories. It is an ergative-absolutive language with S-O-V base word order and rich inflectional morphology. Basque finite verbs and auxiliaries agree with their subject and objects in number, person and case. The direct object of transitive verbs and the subject of unaccusative verbs are both marked with absolutive case, which does not require any inflection (i.e., zero or Ø), while the subjects of transitive and unergative verbs both carry ergative case marking and require case inflection. Typically, case morphology also aligns with thematic roles: the absolutive case indicates patients/themes, while the ergative case indicates agents. Basque verbs can also be distinguished based on their auxiliary: while Basque unaccusatives typically select the auxiliary *izan* (to be), the unergatives and transitives require the auxiliary *ukan* (to have) (Table 1).

Spanish is a Romance language with S-V-O base word order and nominative-accusative case alignment. Spanish verbs agree with their subject in number and person but not in case, which makes Spanish inflectional morphology simpler when compared to Basque. Spanish verbs select the auxiliary *haber* (to have) for compound tenses irrespective of their verb type, while the auxiliary *ser* (to be) is used in passives. Hence, in contrast to Basque, verb type cannot be distinguished based on auxiliary selection in Spanish (Table 1).

English is a Germanic language and, like Spanish, it follows the S-V-O base word order and belongs to the group of languages with the nominative-accusative case alignment system. In line with Spanish, English verbs also agree with their subject in number and person (although their morphological agreement is less complex compared to Spanish or Basque) and require auxiliaries *have* and *be* to form compound tenses or other syntactic structures. Hence, English and Spanish both stand in contrast to Basque when it comes to case-marking different types of argument structures (Table 1).

Table 1. Examples of unergative, unaccusative, and transitive sentences in Basque (the ergative case marking and auxiliary agreement are marked in red; the absolutive auxiliary agreement is marked in blue); ERG = ergative case; ABS = absolutive case; NOM = nominative case; ACC = accusative case; AUX = auxiliary; PPC = *pretérito perfecto compuesto*; PP = past participle (adapted from Heinzova et al., 2023).

Basque	Spanish	English
UNERGATIVES		
Bera-**k** ERG eskiatu **du**. AUX	El NOM ha AUX esqui-ado. PPC	He NOM has AUX ski-ed. PP
She/he skied has.	He has skied.	
She/he has skied.	*He has skied.*	
UNACCUSATIVES		
Bera-Ø ABS erori **da**. AUX	El NOM ha AUX tropez-ado. PPC	He NOM has AUX tripp-ed. PP
She/he fallen is.	He has stumbled.	
She/he has fallen.	*He has stumbled.*	
TRANSITIVES		
Bera-**k** ERG ogia ABS jan **du**. AUX	El NOM ha AUX com-ido PPC el pan. ACC	He NOM has AUX eat-en PP the bread. ACC
She/he the bread eaten has.	He has eaten the bread.	
She/he has eaten the bread.	*He has eaten the bread.*	

1.5.4. Empirical evidence from Basque and Spanish

In contrast to the abundance of research reporting argument structure complexity effects in English (Sections 1.4.1. and 1.4.2.), the empirical evidence from Spanish and Basque is scarce. In this section, we will address those studies in Basque and Spanish that manipulated/contrasted either the number of arguments or the canonicity of argument mapping. This review will aid in identifying the gaps in the state of the art and help to set the grounds for the specific research questions and hypotheses central to the present thesis.

In Section 1.4.3., we have already mentioned a study conducted by Martinez de la Hidalga et al. (2019) that reported slower RTs for unergative compared to unaccusative sentences in a grammaticality judgment task. Crucially, this study implies that, at least in sentence comprehension, unergative sentences may be more costly to process compared to unaccusative sentences. This is in direct contrast to findings from languages with nominative-accusative case alignment, which consistently show higher processing costs associated with unaccusative verbs and sentences. Nevertheless, from this study, we do not have any information about transitive sentences, which also assign the ergative case.

A case study by Pourquié (2013) tested the performance of a Basque-French agrammatic bilingual person while comprehending and producing verbs and sentences with different argument numbers. She reported increased difficulty for Basque items that entail more arguments in the sentence production task. However, since the argument structure complexity effects were not the main focus of the study, the intransitive verbs were not controlled for canonicity of argument mapping (i.e., unaccusative and unergative verbs and sentences were treated as one homogeneous group). Moreover, very few stimuli were provided and these were unequally distributed across conditions making it difficult to assess the argument structure complexity effects.

With regards to Spanish, a pioneering psycholinguistic study by 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 containing unaccusatives compared to unergatives. This suggests that Spanish sentences with unaccusatives might be more difficult to read (possibly as a result of the higher processing costs of the unaccusative argument structure), which would be in line with studies in other nominative-accusative languages as reviewed in Section 1.4.2.

Shifting the focus on Spanish-speaking PWA, a study by Sanchez-Alonso et al. (2011) conducted on a monolingual group of PWA compared the production of sentences with alternating transitives (Section 1.2.1.2.) and their unaccusative counterparts via a picture-elicited sentence completion task. The unaccusative condition elicited more grammatical errors than the transitive condition, implying that Spanish PWA found sentences that include verbs with non-canonical argument mapping more difficult to produce compared to sentences with more arguments. This is in line with previous evidence from a study in Dutch that also compared alternating transitives to corresponding unaccusatives in a sentence comprehension context (Bastiaanse & van Zonneveld, 2005). However, note that the factors of the number of arguments and canonicity of argument mapping are inherently inter-mixed in alternating verbs used in such design.

A later study in Spanish speakers with agrammatic aphasia conducted by Martínez-Ferreiro and colleagues (2014) included not only an unaccusative and a transitive condition of alternating verbs, but also unergatives and unaccusatives without alternating configuration. They tested these four verb groups in action naming and picture-based sentence elicitation. In addition, a picture-matching task that included an unaccusative and a transitive condition of alternating verbs was also administered. Their results in both production tasks showed numerically higher error rates for unaccusatives compared to unergatives, while the error rate pattern of alternating verb groups was mixed across tasks. This implies that when unaccusatives are directly compared to unergatives in Spanish, the pattern is in line with previous cross-linguistic evidence. However, alternating verbs may undergo processing patterns more complex to tease apart.

To sum up, experimental evidence from Spanish suggests that Spanish argument structure processing mechanisms resemble those from other languages studied to date with respect to the canonicity of argument mapping (Section 1.4.2.). Nevertheless, it is unclear how to interpret the existing evidence regarding the contribution of the number of arguments. The evidence from Basque suggests that ergative-absolutive case alignment may lead to different argument structure complexity effects compared to those from languages with a nominative-accusative case alignment. However, we do not have a full picture as to how case assignment interacts with the number of arguments and canonicity of their mapping in Basque.

1.5.5. Specific research questions, hypotheses, and predictions

To our knowledge no study has yet addressed the factor of ergative-absolutive case assignment as a possible contributor to argument structure complexity effects. Additionally, the argument structure complexity effects have not been comprehensively studied in bilingual populations that speak languages with different case alignment systems, which is the case in Basque-Spanish bilinguals. Based on the reviewed theoretical accounts and existing empirical evidence, we reasoned that the differences in case alignment may lead to different patterns of argument structure processing across these two languages. Contrasting Basque and Spanish, which differ in their case alignment systems, in a within-subject design could offer new cross-linguistic evidence with a potential to fill in some of the gaps in the current body of research, and inform theories and thus models of argument structure representation and processing. Hence, the present thesis was set to investigate the following two research questions:

1) *Does ergative case marking increase processing costs for Basque verbs that mark their subject with the ergative case (i.e., unergatives and transitives) as compared to those verbs that assign the absolutive case and thus lack an overt case inflection (i.e., unaccusatives)?*

2) *How do the argument structure complexity effects in Basque differ from those in Spanish and English in neurotypical speakers and speakers with aphasia?*

These questions were addressed through a series of experiments in both neurotypical bilingual Basque-Spanish speakers (Experiments 1 and 2) and in two cases of bilinguals with aphasia: a Basque-Spanish and a Spanish-English speaker (Experiment 3), as each of these populations provides a different perspective on the involvement of case assignment in argument structure processing. While neurotypical speakers inform us about the unimpaired cognitive mechanisms operating on the linguistic units in question, speakers with aphasia can, through the disruption of these mechanisms, expose some of the processing dissociations among the language system components/operations which would otherwise stay hidden.

All the conducted experiments tested the same three verb groups (i.e., unergatives, unaccusatives, and transitives) in both languages of the recruited bilinguals. The verbs were examined in a series of tasks at the lexical, sentence, and connected speech levels of linguistic representation across both production and comprehension. We hypothesized that in Basque, a language with ergative-absolutive case alignment, the unergatives and transitives would elicit higher processing costs due to the ergative case morphology they assign to their subject as compared to unaccusatives that assign the absolutive case and require no overt case morphology. In Spanish and English, we expected to observe the same hierarchy reported in previous experiments, i.e., transitives and/or unaccusatives eliciting higher processing costs as compared to unergatives due to the higher number of arguments and/or non-canonical argument mapping, respectively (Table 2).

Higher processing costs for the hypothesized verb groups were predicted to manifest as higher error rates and/or RTs in comprehension and as higher error rates and/or SOTs in production. If we observed the predicted differences in processing cost patterns in Basque vs. Spanish and/or English, this would imply that ergative case marking is a stronger predictor of argument structure complexity effects than the number of arguments or their mapping.

Table 2. A summary of the factors that we hypothesized could influence verb processing costs (Spanish/English: number of arguments and/or canonicity of thematic mapping; Basque: case assignment) and predicted hierarchies for these processing costs (adapted from Heinzova et al., 2023).

		unergatives	**unaccusatives**	**transitives**	**predicted hierarchy**
	factors				
Spanish/ English	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	ergative (-*k*)	absolutive (Ø)	ergative (-*k*)	unaccusatives < unergatives, transitives

Finally, note that although our experimental samples consist solely of bilingual populations, the same predictions would also hold for monolingual speakers. Since the Basque speakers living in the Basque territory also speak another language (either French or Spanish), a between-subject design targeting two monolingual groups would not be viable. Nevertheless, Basque-Spanish bilinguals are an ideal target population to test in this context as they constitute prototypical representatives of the current Basque speaking population. An additional strength of the present experimental design that targets bilingual speakers is that it provides cross-linguistic evidence while eliminating between-subject variability that could adversely affect the results.

Chapter II. The Experiments

2.1. Experiment 1[1]

This experiment was designed to contrast the processing costs of three verb groups, unergatives, unaccusatives, and transitives, in neurotypical Basque-Spanish bilinguals speaking two languages with distinct case alignment systems. We tested the hypothesis that Basque unergative and/or transitive verbs incur higher processing costs in both comprehension (via a lexical decision task) and production (via a sentence production task) when compared to unaccusatives due to the ergative case marking the unergatives and transitives assign to their subject. The patterns for Spanish were hypothesized to align with previous studies associating higher processing costs with transitives (due to the higher number of arguments) and/or with unaccusatives (due to their non-canonical argument mapping) as compared to unergatives (Table 2 in Section 1.5.5.). Hence, we predicted higher error rates, RTs (in a lexical decision task), and SOTs (in a sentence production task) for unergatives and/or transitives compared to unaccusatives in Basque. In contrast, higher error rates, RTs (in a lexical decision task), and SOTs (in a speech production task) were predicted for transitives and/or unaccusatives as opposed to unergatives in Spanish.

2.1.1. Methods

2.1.1.1. Participants

Seventy-one simultaneous Basque-Spanish bilinguals (19 males) participated in the experiment, ranging in age from 18 to 45 with a mean age of 28 years (standard deviation

[1] This is a modified version of the Accepted Manuscript of an article "Processing argument structure complexity in Basque-Spanish bilinguals" published by Taylor & Francis in *Language, Cognition and Neuroscience*, available at: https://doi.org/10.1080/23273798.2022.2154370

(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 one or both of their languages in family settings 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 (Basque, English and Spanish test; 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 via a grammar test designed for the purpose of this study (Section 2.1.1.3.; see also Appendix A.4.). The final sample of participants, although highly proficient in both languages, was overall more proficient in Spanish than Basque (Table 3). Participants gave written informed consent and received modest monetary compensation for their participation. The study was approved by the BCBL (the Basque Center on Cognition, Brain and Language) Ethics Review Board and complied with the requirements of the Helsinki Declaration.

Table 3. Means, SD 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 (adapted from Heinzova et al., 2023).

	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

2.1.1.2. Stimuli

Spanish and Basque verbs were selected and separately categorized as unergative, unaccusative, or transitive based on criteria appropriate for characteristics of each language (Section 1.2.1.2.). 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 based on Sorace (2000). 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 stimuli 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 (Appendix A.1.). 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 (Section 1.2.1.2.).

The final list of stimuli consisted of 19 verbs and auxiliaries per verb group and language (Appendix A.2.). 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 logarithmic frequency, length, orthographic neighborhood, and cognate status as measured by Levenshtein distance (Appendix A.3.) 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 argument structure (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.

2.1.1.3. Procedure

The experiment was divided into two language blocks. Half of the participants began with the Spanish, while 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 argument structure or general grammar use (Appendix A.4.). 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 gray 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) before the following stimulus 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.

2.1.1.4. 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 (= GLMEMs; for error rates) and linear mixed-effect models (= LMEMs; for log-transformed RTs) with verb type as a predictor (default contrast-coded) using the lme4 package (Bates et al., 2012) in R (R Core Team, 2012), following the linear mixed-effects approach described by Baayen and colleagues (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 (Section 2.1.1.2.). Therefore, we decided to categorize the auxiliary substitution as failure to follow the task instructions rather than a grammatical error. 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 SOTs (Appendix A.5.). 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 inflections reflected as inconsistencies in its use during Basque language acquisition (Ezeizabarrena, 2012; 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' argument structure. In other words, if the processing demands of a verb that assigns the ergative case are too high, these errors are more likely to occur.

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 GLMEMs (for error rates) and LMEMs (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 GLMEM to a dataset where one of the conditions was a perfect predictor of the outcome. The analysis scripts are available at: https://osf.io/t9pz5/?view_only=11929d2bc5784298b746c5038c02bfbe

2.1.2. Results

2.1.2.1. Lexical decision task

In the lexical decision task, error rates reached 2.38% in Spanish (unergatives: 3.93%, unaccusatives: 1.96%, transitives: 1.26%) and 8.77% in Basque (unergatives: 8.38%, unaccusatives: 7.19%, transitives: 9.27%) (Figure 6). 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 (Table 4).

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).

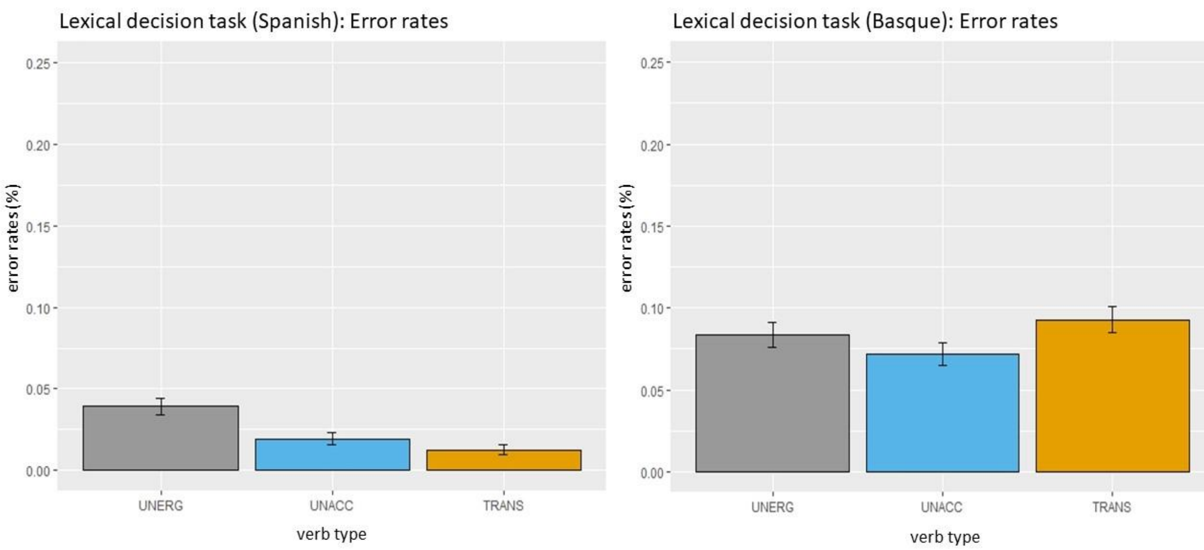


Figure 6. Percentage of errors in the Spanish and Basque lexical decision tasks for each verb type; error bars indicate the standard error of the mean (adapted from Heinzova et al., 2023).

The mean RTs for the lexical decision task were 0.73 s in Spanish (unergatives: 0.74 s, unaccusatives: 0.73 s, transitives: 0.72 s) and 0.92 s in Basque (unergatives: 0.92 s, unaccusatives: 0.93 s, transitives: 0.91 s) (Figure 7). The LMEMs showed no significant difference in RTs for different verb types in either language (Table 4).

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).

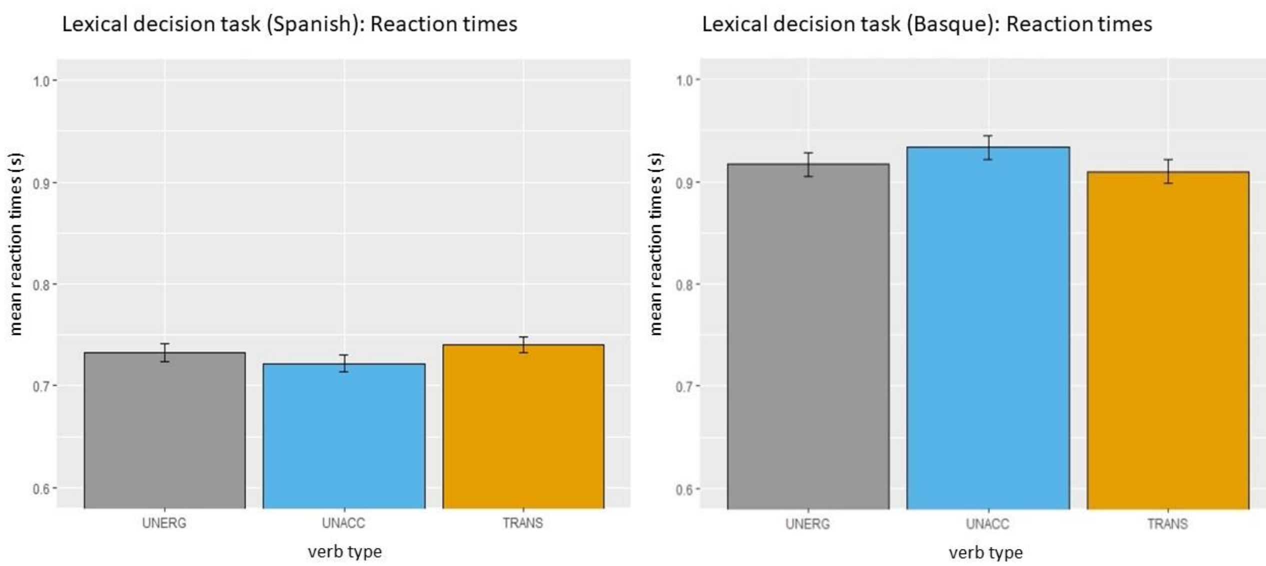


Figure 7. Mean RTs (s) for each verb type in the Spanish and Basque lexical decision tasks; error bars indicate the standard error of the mean (adapted from Heinzova et al., 2023).

Table 4. Fitted LMEMs and GLMEMs for the lexical decision task 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 (adapted from Heinzova et al., 2023).

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

2.1.2.2. Sentence production task

As for error rates in the sentence production task, participants overall produced 0.19% ungrammatical sentences in Spanish (unergatives: 0%, unaccusatives: 0.26%, transitives:

0.33%) and 5.90% in Basque (unergatives: 10%, unaccusatives: 3.41%, transitives: 4.34%) (Figure 8).

In Spanish, GLMEM analysis showed no significant differences among the three verb types in terms of error rates (Table 5). 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 (Table 5) 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 (unergatives: 1.50 s; unaccusatives: 1.59 s; transitives: 1.55 s) and 1.96 s in Basque (unergatives: 1.94 s; unaccusatives: 1.99 s; transitives: 1.96) (Figure 9). 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 (Table 5).

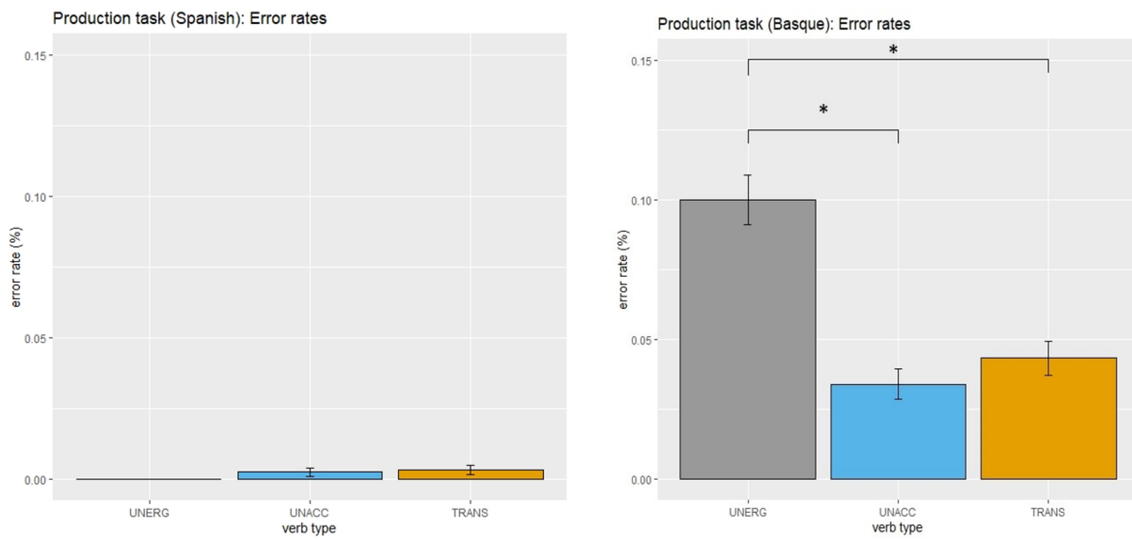


Figure 8. Error rates (%) for each verb type in the sentence production task in both Spanish and Basque; the asterisks denote significant differences between the two verb types (adapted from Heinzova et al., 2023).

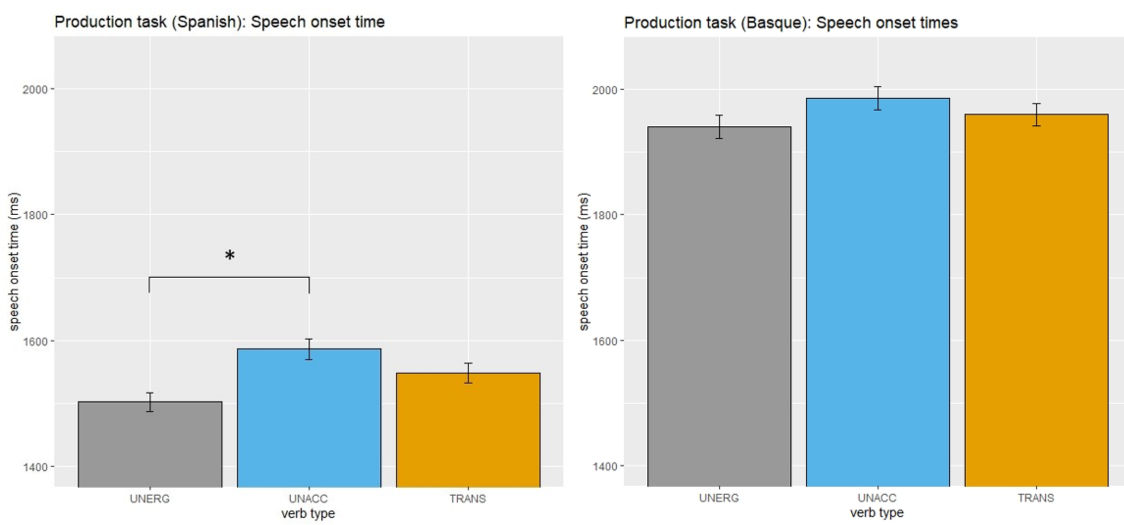


Figure 9. Mean SOTs (ms) for each verb type in the sentence production task in both Spanish and Basque; the asterisks denote significant differences between the two verb types (adapted from Heinzova et al., 2023).

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).

Table 5. Fitted LMEMs and GLMEMs 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 function rounds the values down to 1; the asterisks denote statistical significance (adapted from Heinzova et al., 2023).

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

2.1.3. Discussion

The present study compared the processing costs of three verb groups (unergatives, unaccusatives, and transitives) that vary in terms of argument structure configuration in simultaneous Basque-Spanish bilinguals speaking languages with distinct case alignment systems. Our hypothesis predicted the following patterns for the two languages: In Basque, unaccusatives would be easier to process due to their absolutive case marking and no overt inflection requirement than unergatives and/or transitives, which both mark their subjects with the ergative case (i.e., unaccusatives < unergatives, transitives). This pattern of results was not predicted for Spanish, where the hierarchy was expected to 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 processing cost associated with verb comprehension and a sentence production task to test the processing cost of argument structure production at the sentence level.

The results from the lexical decision task showed no effect of verb type in either language, going against our initial hypothesis. However, the error rate 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 Experiment 1.

2.1.3.1. The lexical decision vs. the sentence production task: Divergent outcomes

The null results obtained in the lexical decision task for both languages go along with previous studies on agrammatic aphasia, where varying argument structure 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 judgment, 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 argument structure 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 argument structure becomes more complex, more time is required for processing, and the chance of failing to access the argument structure information increases. Thus, in the attempt to recall and produce verbs and sentences with more complex argument structure in action naming and sentence elicitation tasks, both language-impaired and non-impaired speakers face increased difficulties (e.g., 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, assuming that the computational demands and processing routines for language production are higher. At first glance, this explanation appears to be inconsistent with studies reporting argument structure 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 and colleagues (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, lexicalist approaches to argument structure (e.g., Chomsky, 1981; Jackendoff, 1972; Levin & Rappaport, 1986; Williams, 1981; among others) assume that recognizing an existing verb phrase requires access to its unique lexical representation, including argument structure 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 argument structure 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; 1999b), 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 argument structure 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 had introduced time pressure or other kinds of task demands, more notable differences would have emerged between 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.

2.1.3.2. The sentence production task: Error rates

In the Basque sentence production task, the number of ungrammatical sentences produced with unergatives was significantly higher than that generated by unaccusatives and transitives. 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 in Basque 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.

According to our initial hypothesis, the case assignment could increase processing costs in unergative and transitives verbs in Basque. If the case 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 case assignment itself does not render sentences more prone to grammatical errors. Hence, we reasoned that the increased error rate in unergative verbs might be due to “the apparent mismatch” that arises when ergative case marking typical for transitive sentences occurs 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 grammatical errors produced in Basque, see Appendix A.6.). However, this hypothesis needs further testing.

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 and colleagues (2019) argued 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 GLMEMs 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 (Appendix A.7.). 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 argument structure 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. noncognate verbs across verb groups, we concluded that cognate status *per se* was not responsible for the tendency to omit ergative case marking (Appendix A.8.).

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 (Appendix A.6.). 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.

2.1.3.3. The sentence production task: SOTs

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 *Unaccusative Hypothesis* (e.g., Burzio, 1986; Perlmutter, 1978) 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 argument 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 indicate that argument structure information can be utilized at the level of pre-speech and/or on-line sentence planning (Lee & Thompson, 2011; Lindsley, 1975) and, more interestingly, that verbs are 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 and colleagues (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, arguably 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 *Unaccusative 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 may require 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 common to transitive structures; we argued that this "apparent mismatch" between the intransitive meaning of unergatives and their morphology typical of transitive verbs might increase their processing costs. 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 the "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 argument structure processing requirements on the one hand and planning-related constraints 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 argument structure complexity and planning constraints 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 argument structure processing in ergative-absolutive languages like Basque, more 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 (Appendix A.9.). 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 nominative-accusative languages, is not present in Basque, a language with ergative-absolutive alignment system.

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 (Appendix A.7.). 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.

2.1.3.4. The non-convergent results

One of the interpretative challenges the results of Experiment 1 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 argument structure complexity and planning constraints 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 argument structure processing. Hence, the results of Experiment 1 should be understood as initial evidence pointing to possible argument structure processing differences between the two languages and as a prompt to encourage further experiments on this topic.

2.1.3.5. Limitations

The reported results may suffer from some further limitations related to cross-language and cross-dialectal interference as well as the auxiliary alternations in Basque, which will be discussed in this section. Additionally, the uneven representation of tasks targeting word and sentence levels of linguistic representation across production and comprehension domains will also be addressed.

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 argument structure 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 argument structure 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 (Appendix A.8.). However, as apparent from the auxiliary acceptability ratings (Section 2.1.1.2.), there is relatively high variability amongst Basque speakers in their use of the ergative case and auxiliaries independent of dialectal variation which certainly might have impacted our results.

Another factor that could have potentially affected our results are the 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 argument structure. 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.

Finally, since only one lexical task in comprehension and one sentence-level task in production were administered in Experiment 1, we were unable to tease apart the impact of task and domain on the observed effects. To overcome this limitation, we designed Experiment 2 which included lexical and sentence-level tasks in both domains, allowing us to separate the contribution of each of these experimental conditions.

2.2. Experiment 2

The first objective of Experiment 2 was to bring more support for our initial hypothesis that Basque and Spanish would each give rise to different patterns of argument structure complexity effects due to the differences in their case alignment systems (Section 1.5.5). The second objective was to test our more specific hypotheses arising from the outcomes of Experiment 1 that a) Basque unergatives elicit higher error rates than unaccusatives and transitives due to the "apparent mismatch" between their transitive morpho-syntactic properties and intransitive semantics (Section 2.1.3.2.), and b) Spanish unaccusatives elicit longer SOTs compared to unergatives due to more costly advance planning of their object-like subjects (Section 2.1.3.3.). The final objective of Experiment 2 was to bring evidence from both single-word and sentence levels of linguistic representation across the production and comprehension domains (Section 2.1.3.5.).

To achieve these objectives, Experiment 2 comprised a set of four distinct tasks targeting speech production (i.e., an action naming task and a sentence elicitation task) and comprehension (i.e., a verb-picture verification task and a sentence picture verification task) in a similar sample of neurotypical, simultaneous Basque-Spanish bilinguals to the one recruited for Experiment 1. To facilitate a cross-domain and cross-level evaluation of argument structure complexity effects in each language, all verbs and visual stimuli were repeated across these four tasks.

As in Experiment 1, different patterns of performance were predicted for Basque and Spanish. Specifically, we anticipated higher error rates and SOTs (in production) and RTs (in comprehension) for unergatives and/or transitives in Basque due to their ergative case assignment. Higher processing costs (also reflected by higher error rates, SOTs, and RT measures) for unaccusatives and/or transitives were expected in Spanish, driven by the non-canonical argument mapping and/or by the higher number of arguments. Since the tasks employed in Experiment 2 were different from the tasks in Experiment 1, we did not have strong, task-specific predictions. However, argument structure complexity effects were anticipated especially at the sentence level in production (i.e., the sentence elicitation task) while being less likely to occur at the single-word level in comprehension (i.e., verb-picture verification task), which would replicate our findings in Experiment 1.

2.2.1. Methods

2.2.1.1. Participants

Forty neurotypical, simultaneous Basque-Spanish bilinguals (15 males), ranging in age from 19 to 45 with a mean age of 29.4 years (SD = 7.04) were recruited for the experiment. They were all highly proficient speakers of both languages and acquired either Basque or both Basque and Spanish as their first language. The majority of participants received their formal education in Basque. The recruitment criteria were: 1) a minimum high school education, 2) Basque (or both Basque and Spanish) as the first language in order of acquisition, 3) a minimum score of 55 (scale: 0–65) in the proficiency measure BEST (de Bruin et al., 2017), and 4) a minimum score of 5 (scale: 1–5) in language interviews in both Spanish and Basque. Additionally, we also compared their LexTale scores (Lemhöfer & Broersma, 2012) and mean exposure to each language (based on the self-reported exposure scores from the BCBL participants' database, where percentage of daily use of both languages in writing, speaking, reading, and listening was reported). The final sample of participants, although highly proficient in both languages and with lower age of acquisition in Basque, was overall more proficient in Spanish as indicated by the BEST proficiency scores (Table 6). All participants gave written informed consent and received 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 6. Means (SD), and range of proficiency scores for participants in each language and between-language statistical comparisons (paired two sample *t*-tests) for selected proficiency measures (with *t*- and *p*-values reported).

	Basque			**Spanish**			***t*-test**	
measure (min–max)	**Mean**	**SD**	**Range**	**Mean**	**SD**	**range**	***t*-value**	***p*-value**
BEST (0–65)	63	2.44	55–65	64.48	1.36	57–65	3.25	< .01
LexTale (0–100%)	64	1.40	47–100	64.50	1.36	78–100	1.69	0.09
mean exposure (0–100%)	42.46	15.16	10–80	46.13	15.45	10–75	0.93	0.3
age of acquisition	0	0	0–0	0.72	1. 19	0–3	3.83	< .01

2.2.1.2. Stimuli

Basque and Spanish unergative, unaccusative, and transitive verbs, easily visualized in a drawing, were pre-selected and subsequently depicted by an artist as simple, colorful illustrations. These drawings of actions were presented in two separate name agreement ratings (one for each language), administered via an online rating platform, to 100 Basque-Spanish bilinguals (50 respondents per language) drawn from the same participant pool (the BCBL participant database) and with a similar linguistic profile as the tested participants. In these ratings, respondents were asked to provide written labels (the most suitable verb) for pictures of actions in the given language and to rate the visual complexity of each drawing on the scale from 1 to 5. All the drawings that had a name agreement higher than 60% were further examined by two independent linguists native to the language tested for the purpose of verb classification. These linguists were asked to assess if they perceive the depicted action as transitive or intransitive. For the intransitive actions, they were asked to categorize the verb as unergative or unaccusative based on semantic criteria (Sorace, 2000). In Basque, auxiliary selection and ergative case markings (whether the verb selects the auxiliary *izan* / *to be* or *ukan* / *to have* and whether it assigns the ergative case to its subject) was also used as a classification criterion (Laka, 1996).

Based on this classification, we selected a final list of 27 verbs (9 for unergative, 9 for unaccusative, and 9 for transitive verbs) and their corresponding action drawings per language (Appendix B.1.). These drawings were further controlled for visual complexity and the verbs matched on logarithmic frequency, length (in syllables) and cognate status as measured by Levenshtein distance (Appendix B.2.) to prevent these visual and psycholinguistic factors from skewing our results (Section 1.4.). The same drawings were used as visual stimuli for the production and comprehension tasks (Figure 10).

For the comprehension tasks, we created recordings of selected verbs in isolation (used in the verb-picture verification task) as well as in sentence environments (used in the sentence-verification task). The auditory stimuli, recorded by two female Basque-Spanish bilingual speakers (one for Basque and one for Spanish stimuli) were used to create both congruent and incongruent trials (Appendix B.3.).

Figure 10. Examples of congruent and incongruent visual and auditory (transcribed into text) stimuli used for the sentence-picture verification task in Basque (an unaccusative verb *erori* / *to fall*) and Spanish (an unergative verb *correr* / *to run*).

2.2.1.3. Procedure

The experiment was divided into two sessions that took place on different days with an interval minimum of two days and maximum two weeks. Each session was divided into two language blocks (Spanish and Basque). Half of the participants began with the Spanish while the other half began with the Basque block. Upon giving their informed consent in the language of their first block, participants were seated in a behavioral cabin in front of a laptop and asked to put on headphones with a microphone. All the tasks were coded and run using *Psychopy*, version 3.0 (Peirce, 2007). Before each task, written instructions in the language corresponding to the administered block appeared on the screen and participants were offered further clarification by the experimenter if needed.

The first block of the first session started with two production tasks: action naming and story elicitation, followed by three comprehension tasks: verb-picture verification, sentence-picture verification and story-picture verification (the results of the story elicitation and story-picture verification tasks are not reported in this thesis due to extensive transcription and scoring procedures and ongoing analyses). Upon completing the first block, each participant was offered a short break and the second block followed. The entire session, including the instructions, both language blocks, and a short break, lasted approximately 45–50 minutes.

The first block of the second session started in the opposite language of the first block of the previous session. This block had the same structure and the same task order as the first session with the exception of the sentence elicitation task, which was administered in place of the action naming task. Hence each session included the same number of tasks (five per block), with production tasks followed by comprehension tasks ordered so as to progressively increase the complexity within each domain (for details on each task, see Appendix B.3.).

2.2.1.4. Data analysis

The error rates measured for all tasks, SOTs for production tasks, and RTs for comprehension tasks were all treated as dependent variables. These variables were analyzed by fitting generalized (for error rates) and linear mixed-effect models (for log-transformed RTs and SOTs) with the verb type as a predictor (default contrast-coded) using the lme4 package (Bates et al., 2012) in R (R Core Team, 2012), following the linear mixed-effects approach described by Baayen and colleagues (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-item and by-subject, respectively) until convergence was reached. For RTs and SOTs, linear model assumptions were checked and non-homoscedasticity of the residuals was corrected by log-transformation. Finally, false discovery rate-corrected contrasts among levels of verb type were carried out using the emmeans package (Lenth et al., 2018).

For the action naming task, error rates and SOTs were analyzed from all 39 participants (one participant was excluded from the analysis due to a technical failure during data collection). The recorded oral responses were transcribed and scored to obtain the error rates. An item was scored as correct if the produced verb was either identical with the target verb or different, but semantically acceptable (e.g., *masticar* / *to chew* would be an acceptable substitute for the verb *morder* / *to bite*). An item was scored as incorrect if the participant failed to produce the full verb within the limit of 3500 ms or if a noun or other word category was produced instead. Only the responses scored as correct (92.12% in Spanish, 83.10% in Basque) in the error rate analysis were included in the SOT analysis. The SOTs were extracted from the audio recordings of participants' responses using *Chronset* (Roux et al., 2016) and all the generated SOTs were manually checked.

For the sentence elicitation task, the error rates and SOTs were analyzed from 36 participants (four participants were excluded from the analysis: three due to a technical failure during data collection and one due to her absence from the second scheduled session). The recordings of the oral responses were transcribed and scored. An item was scored as correct if the produced sentence was grammatically sound and complete (i.e., including at least a subject and a verb), if the used verb was identical with the target verb or a semantically acceptable substitute, and finally, if the utterance was completed within the time limit of 5000 ms. Only the responses scored as correct (95.95% in Spanish; 75.62% in Basque) were included in the SOT analysis. The SOTs were extracted following the same procedure as in the action naming task.

The final analysis of both comprehension tasks included data from 39 participants (one participant was absent from the second session). For the error rate analysis, an item was accepted as correct if the trial was correctly identified as congruent in the congruent condition or as incongruent in the incongruent condition. For the RT analysis, we included only the correct responses (verb-picture verification: 99.34% in Spanish and 98.48% in Basque; sentence-picture verification task: 98.01% in Spanish and 97.06% in Basque).

2.2.2. Results

2.2.2.1. Action naming task

In the action naming task, the error rates reached 7.60% in Spanish (unergatives: 3.99%; unaccusatives: 12.25%; transitives: 6.55%) and 15.76% in Basque (unergatives: 17.95%; unaccusatives 20.51%; transitives: 8.83%) (Figure 11).

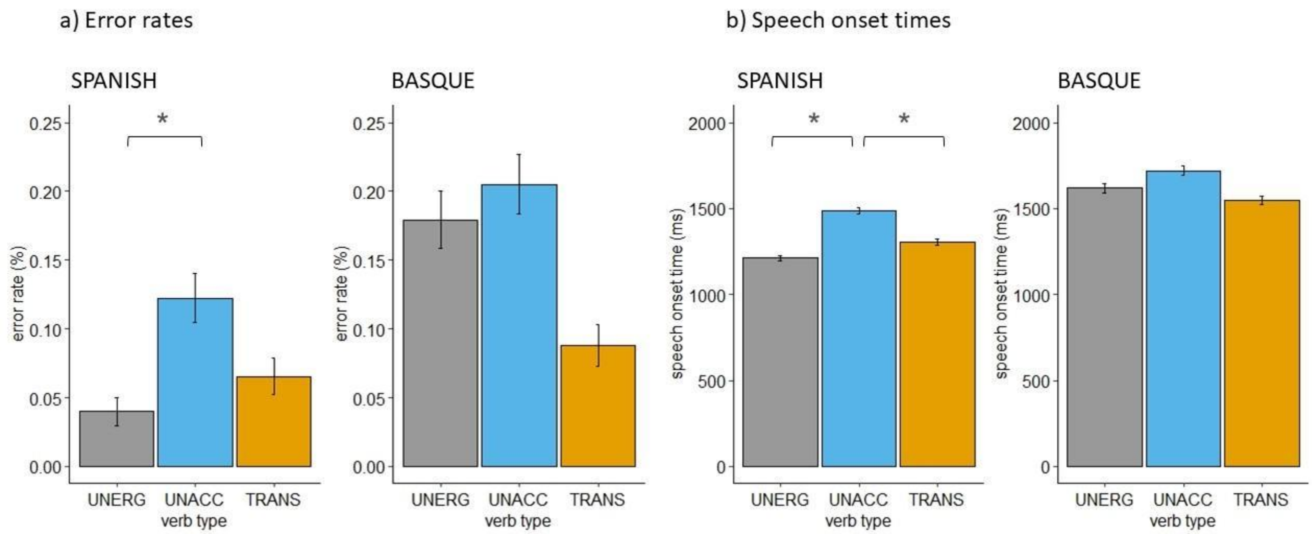


Figure 11. Mean error rates in % (a) and SOTs in ms (b) for each verb type in the action naming task in Spanish and Basque; the asterisks denote significant differences between verb types.

The GLMEMs revealed verb type to be a significant predictor of error rates in Spanish with significantly higher error rates for unaccusatives compared to unergatives. We found no effect of verb type on error rates in Basque (Table 7).

Additionally, Bayesian inferential methods were used to assess whether the null results for error rates obtained in Basque 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 Basque (transitive vs. unaccusative: BF = 0.65; transitive vs. unergative: BF = 0.27; unergative vs. unaccusative: BF = 0.13).

Table 7. Fitted LMEMs and GLMEMs for the action naming tasks in Spanish and Basque; *p*-values are Bonferroni corrected for multiple comparisons (note that Bonferroni correction adjustment can result in *p*-values > 1, in which case the *emmeans* function rounds the values down to 1) and asterisks denote statistical significance.

Action naming task (Spanish)

Error rates				
Model	**glmer** (error ~ verb type (1|subject) + (1|item))			
Contrast	**estimate**	**SE**	***z*-ratio**	***p*-value**
transitive : unaccusative	-1.213	0.595	-2.040	.1241
transitive : unergative	-0.467	0.624	-0.721	1.0000
unaccusative : unergative	-1.680	0.624	-2.691	.0214*
Speech onset times				
Model	**lmer** (log(SOT) ~ verb type (1|subject) + (1|item))			
Contrast	**estimate**	**SE**	***t*-ratio**	***p*-value**
transitive : unaccusative	-0.1275	0.0476	-2.680	.0357*
transitive : unergative	-0.0747	0.0475	-1.574	.3782
unaccusative : unergative	-0.2022	0.0475	-4.254	.0006*

Action naming task (Basque)

Error rates				
Model	**glmer** (error ~ verb type (1|subject) + (1|item))			
Contrast	**estimate**	**SE**	***z*-ratio**	***p*-value**
transitive : unaccusative	-1.101	0.540	-2.038	.1246
transitive : unergative	-0.774	0.546	-1.418	.2345
unaccusative : unergative	-0.327	0.527	-0.620	.5352
Speech onset times				
Model	**lmer** (log(SOT) ~ verb type (1|subject) + (1|item))			
Contrast	**estimate**	**SE**	***t*-ratio**	***p*-value**
transitive : unaccusative	-0.1254	0.0775	-1.618	.3483
transitive : unergative	0.0710	0.0775	0.916	1.0000
unaccusative : unergative	-0.0545	0.0777	-0.701	1.0000

The mean SOTs were 1.33 s in Spanish (unergatives: 1.21 s; unaccusatives: 1.49 s; transitives: 1.31 s) and 1.63 s in Basque (unergatives: 1.62 s; unaccusatives: 1.72 s; transitives: 1.55 s) (Figure 11). The LMEMs showed verb type to be a significant predictor of SOTs in Spanish with unaccusatives eliciting significantly higher SOTs compared to both unergatives and transitives. In Basque, we found no significant effect of verb type on SOTs (Table 7) and BFs confirmed moderate to strong evidence in favor of the null hypothesis (transitive vs. unaccusative: BF = 0.20; transitives vs. unergative: BF = 0.09; unergative vs. unaccusative: BF = 0.06).

2.2.2.2. Sentence elicitation task

The error rates in the sentence elicitation task reached 5.05% in Spanish (unergatives: 1.86%; unaccusatives: 5.86%; transitives: 7.41%) and 23.8% in Basque (unergatives: 27.78%; unaccusatives 20.68%; transitives: 23.15%) (Figure 12).

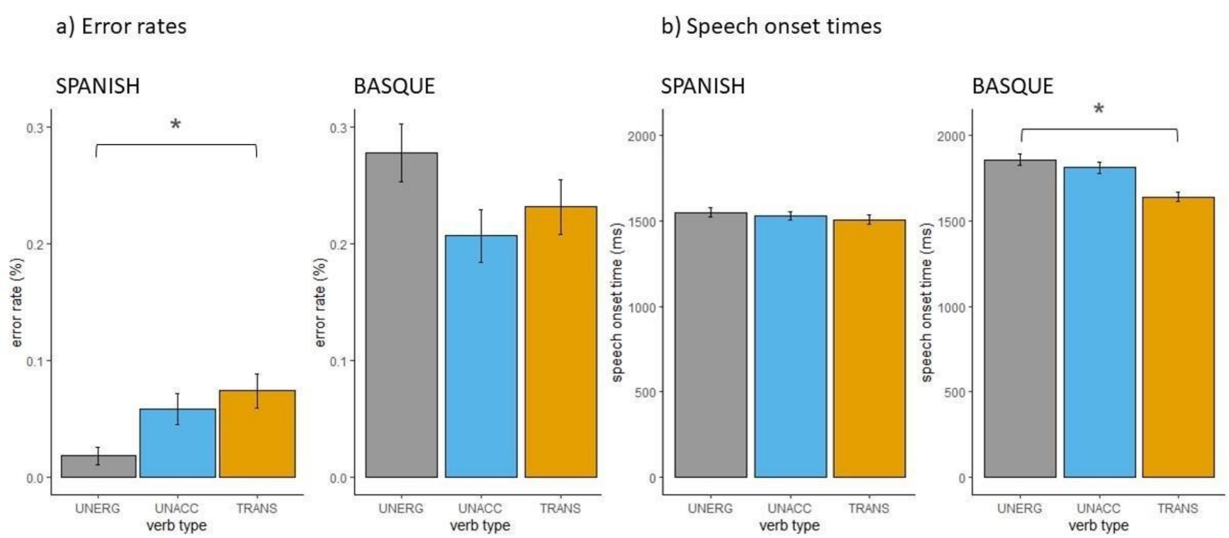


Figure 12. Mean error rates in % (a) and SOTs in ms (b) for each verb type in the sentence elicitation task in Spanish and Basque; the asterisks denote significant differences between verb types.

In Spanish, the GLMEMs showed the verb type to be a significant predictor of error rates with transitives eliciting higher error rates than unergatives. In Basque, we found no effect of verb type (Table 8). Additionally, the BFs confirmed moderate evidence for the null hypothesis (transitive vs. unaccusative: BF = 0.13; transitive vs. unergative: BF = 0.21; unergative vs. unaccusative: BF = 0.41).

Table 8. Fitted LMEMs and GLMEMs for the sentence elicitation task in Spanish and Basque; *p*-values are Bonferroni corrected for multiple comparisons (note that Bonferroni correction adjustment can result in *p*-values > 1, in which case the *emmeans* function rounds the values down to 1) and asterisks denote statistical significance.

Sentence elicitation task (Spanish)

Error rates

Model	**glmer** (error ~ verb type (1|subject) + (1|item))			
Contrast	**estimate**	**SE**	***z*-ratio**	***p*-value**
transitive : unaccusative	0.299	0.540	0.553	1.000
transitive : unergative	-1.782	0.665	-2.679	.0222*
unaccusative : unergative	-1.483	0.672	-2.209	.0816

Speech onset times

Model	**lmer** (log(SOT) ~ verb type (1+type|subject) + (1|item))			
Contrast	**estimate**	**SE**	***t*-ratio**	***p*-value**
transitive : unaccusative	-0.0137	0.0443	-0.309	1.0000
transitive : unergative	0.0128	0.0428	0.298	1.0000
unaccusative : unergative	-0.0009	0.0433	-0.021	1.0000

Sentence elicitation task (Basque)

Error rates

Model	**glmer** (error ~ verb type (1 + verb type|subject) + (1 + verb type|item))			
Contrast	**estimate**	**SE**	***z*-ratio**	***p*-value**
transitive : unaccusative	0.739	0.504	1.466	.4276
transitive : unergative	0.558	0.426	1.309	.5714
unaccusative : unergative	0.181	0.529	0.342	1.0000

Speech onset times

Model	**lmer** (log(SOT) ~ verb type (1|subject) + (1|item))			
Contrast	**estimate**	**SE**	***t*-ratio**	***p*-value**
transitive : unaccusative	-0.1062	0.0479	-2.216	.1044
transitive : unergative	-0.1220	0.0480	-2.541	.0500*
unaccusative : unergative	0.0158	0.0481	0.330	1.0000

The mean SOTs in the sentence elicitation task were 1.53 s in Spanish (unergatives: 1.55 s; unaccusatives: 1.53 s; transitives: 1.51 s) and 1.77 s in Basque (unergatives: 1.86 s; unaccusatives 1.81 s; transitives: 1.64 s) (Figure 12). The LMEMs showed no effects of verb type on SOTs in Spanish and the BFs confirmed strong evidence in favor of the null hypothesis in Spanish (transitive vs. unaccusative: BF = 0.03; transitive vs. unergative: BF = 0.03; unergative vs. unaccusative: BF = 0.03). There was an effect of verb type in Basque, specifically, unergatives elicited higher SOTs compared to transitives (Table 8).

2.2.2.3. Verb-picture verification task

The error rates in the verb-picture verification task reached 0.66% in Spanish (unergatives: 0.71%; unaccusatives: 0.43%; transitives: 0.85%) and 1.51% in Basque (unergatives: 0.14%; unaccusatives 1.00%; transitives: 3.42%) (Figure 13).

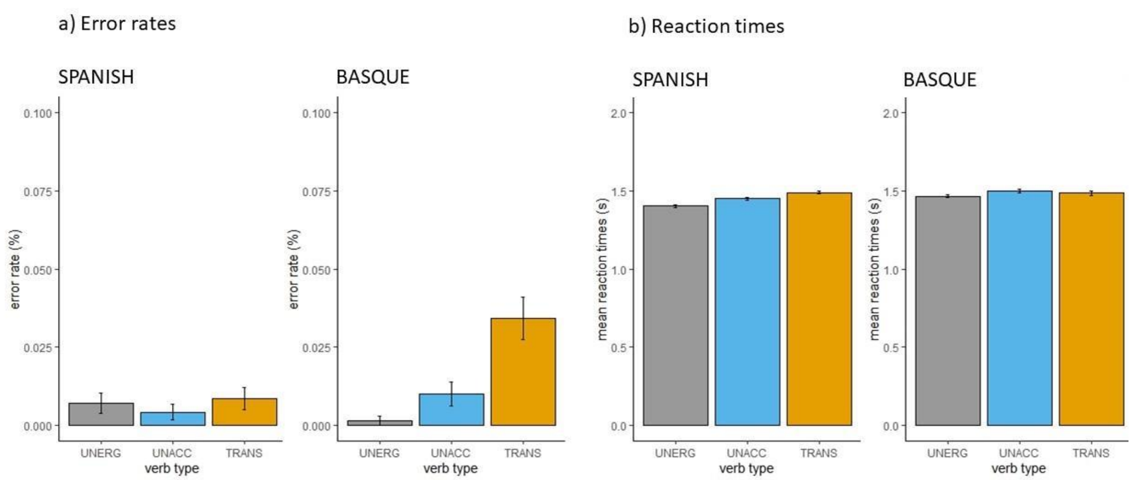


Figure 13. Mean error rates in % (a) and mean RTs in s (b) for each verb type in the verb-picture verification task in Spanish and Basque.

The GLMEMs showed that verb type was not a significant predictor of error rates in either Spanish or Basque (Table 9) and the BFs revealed moderate evidence for the null hypothesis in Spanish (transitive vs. unaccusative: BF = 0.20; transitive vs. unergative: BF = 0.12; unergative vs. unaccusative: BF = 0.17) and weak to moderate evidence for the null in Basque (transitive vs. unaccusative: BF = 0.20; transitive vs. unergative: BF = 3.22; unergative vs. unaccusative: BF = 1.06).

Table 9. Fitted LMEMs and GLMEMs for the verb-picture verification task in Spanish and Basque; *p*-values are Bonferroni corrected for multiple comparisons (note that Bonferroni correction adjustment can result in *p*-values > 1, in which case the *emmeans* function rounds the values down to 1).

Verb-picture verification task (Spanish)

Error rates

Model	**glmer** (error ~ verb type (1|subject) + (1|item))			
Contrast	**estimate**	**SE**	***z*-ratio**	***p*-value**
transitive : unaccusative	0.693	0.751	0.922	1.000
transitive : unergative	-0.176	0.657	-0.268	1.000
unaccusative : unergative	0.517	0.772	0.669	1.000

RTs

Model	**lmer** (log(RT) ~ verb type (1|subject) + (1|item))			
Contrast	**estimate**	**SE**	***t*-ratio**	***p*-value**
transitive : unaccusative	0.0220	0.0305	0.720	1.0000
transitive : unergative	0.0575	0.0305	1.882	.1950
unaccusative : unergative	-0.0355	0.0305	-1.163	.7498

Verb-picture verification task (Basque)

Error rates

Model	**glmer** (error ~ verb type (1|subject) + (1|item))			
Contrast	**estimate**	**SE**	***z*-ratio**	***p*-value**
transitive : unaccusative	0.609	0.825	0.739	1.0000
transitive : unergative	-2.764	1.251	-2.210	.0813
unaccusative : unergative	-2.154	1.282	-1.681	.2784

RTs

Model	**lmer** (log(RT) ~ verb type (1|subject) + (1|item))			
Contrast	**estimate**	**SE**	***t*-ratio**	***p*-value**
transitive : unaccusative	-0.00932	0.0180	-0.519	1.0000
transitive : unergative	0.01017	0.0180	0.566	1.0000
unaccusative : unergative	-0.01949	0.0179	-1.087	.8586

The mean RTs in the verb-picture verification task were 1.45 s in Spanish (unergatives: 1.40 s; unaccusatives: 1.45 s; transitives: 1.49 s) and 1.48 s in Basque (unergatives: 1.46 s; unaccusatives 1.50 s; transitives: 1.48 s) (Figure 13). The LMEMs revealed no effects of verb type on RTs in Spanish or Basque (Table 9) and the BFs confirmed moderate to strong evidence in favor of the null hypothesis in Spanish (transitive vs. unaccusative: BF = 0.05; transitive vs. unergative: BF = 0.22; unergative vs. unaccusative: BF = 0.28) and strong evidence for the null in Basque (transitive vs. unaccusative: BF = 0.02; transitive vs. unergative: BF = 0.03; unergative vs. unaccusative: BF = 0.04).

2.2.2.4. Sentence-picture verification task

The error rates in the sentence-picture verification task reached 1.99% in Spanish (unergative: 1.57%; unaccusative: 2.99%; transitive: 1.42%) and 2.94% in Basque (unergative: 2.42%; unaccusative 1.28%; transitive: 5.13%) (Figure 14).

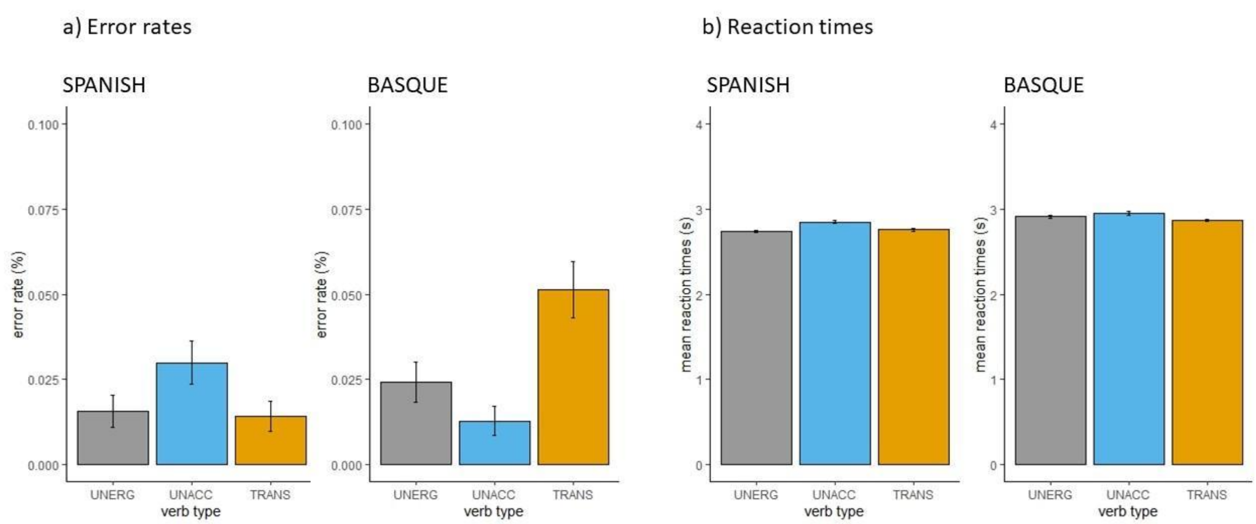


Figure 14. Mean error rates in % (a) and mean RTs in s (b) for each verb type in the sentence-picture verification task in Spanish and Basque.

The GLMEMs showed that verb type was not a significant predictor of error rates in Spanish or Basque (Table 10) and the BFs confirmed moderate evidence for the null hypothesis in both Spanish (transitive vs. unaccusative: BF = 0.16; transitive vs. unergative: BF = 0.19; unergative vs. unaccusative: BF = 0.15) and Basque (transitive vs. unaccusative: BF = 0.20; transitive vs. unergative: BF = 0.18; unergative vs. unaccusative: BF = 0.65).

Table 10. Fitted LMEMs and GLMEMs for the verb-picture verification task in Spanish and Basque; *p*-values are Bonferroni corrected for multiple comparisons (note that Bonferroni correction adjustment can result in *p*-values > 1, in which case the *emmeans* function rounds the values down to 1).

Sentence-picture verification task (Spanish)

Error rates				
Model	**glmer** (error ~ verb type (1|subject) + (1|item))			
Contrast	**estimate**	**SE**	***z*-ratio**	***p*-value**
transitive : unaccusative	-0.278	0.846	-0.329	1.000
transitive : unergative	0.488	0.844	0.578	1.000
unaccusative : unergative	0.209	0.835	0.251	1.000

RTs				
Model	**lmer** (log(RT) ~ verb type (1|subject) + (1|item))			
Contrast	**estimate**	**SE**	***t*-ratio**	***p*-value**
transitive : unaccusative	-0.03188	0.0261	-1.223	.6801
transitive : unergative	-0.00273	0.0264	0.103	1.0000
unaccusative : unergative	-0.03461	0.0264	-1.309	.5883

Sentence-picture verification task (Basque)

Error rates				
Model	**glmer** (error ~ verb type (1|subject) + (1|item))			
Contrast	**estimate**	**SE**	***z*-ratio**	***p*-value**
transitive : unaccusative	1.328	0.735	1.807	.2121
transitive : unergative	-0.447	0.676	-0.662	1.0000
unaccusative : unergative	0.881	0.753	1.170	.7256

RTs				
Model	**lmer** (log(RT) ~ verb type (1|subject) + (1|item))			
Contrast	**estimate**	**SE**	***t*-ratio**	***p*-value**
transitive : unaccusative	-0.01963	0.0273	-0.720	1.0000
transitive : unergative	-0.01053	0.0273	-0.386	1.0000
unaccusative : unergative	-0.00911	0.0273	-0.334	1.0000

The mean RTs in the sentence-picture verification task were 2.78 s in Spanish (unergatives: 2.74 s; unaccusatives: 2.85 s; transitives: 2.76 s) and 2.91 s in Basque (unergatives: 2.91 s; unaccusatives 2.95 s; transitives: 2.87 s) (Figure 14). The LMEMs revealed no effects of verb type on RTs in Spanish or Basque (Table 10) and the BFs confirmed moderate to strong evidence in favor of the null hypothesis in Spanish (transitives vs. unaccusatives: BF = 0.08; transitives vs. unergatives: BF = 0.03; unergatives vs. unaccusatives: BF = 0.10) and strong evidence for the null in Basque (transitives vs. unaccusatives: BF = 0.05; transitives vs. unergatives: BF = 0.04; unergatives vs. unaccusatives: BF = 0.04).

2.2.3. Discussion

In Experiment 2, we tested highly proficient Basque-Spanish neurotypical, simultaneous bilinguals in production and comprehension of unergative, unaccusative and transitive verbs across tasks targeting both lexical and sentence levels of linguistic representation. Different patterns of performance were predicted for Basque and Spanish due to the different ways in which these two languages encode argument structure with respect to their case alignment systems. We predicted higher error rates, SOTs (in production), and RTs (in comprehension) for Basque unergatives and/or transitives vs. unaccusatives due to their ergative case assignment. Spanish unaccusatives and/or transitives were expected to incur higher processing costs than unergatives, reflecting their non-canonical argument mapping and/or a higher argument number, respectively. In the discussion for Experiment 1, we further hypothesized that the production of unergatives may be especially problematic in Basque, due to the mismatch of their intransitive semantics clashing with transitive grammatical properties (Section 2.1.3.2.). For Spanish, unaccusatives were hypothesized to incur higher SOTs due to the required advanced planning of their object-like subject (Section 2.1.3.3.). Hence, the main objective of Experiment 2 was to bring more support for these hypotheses across a wider range of tasks.

The results of Experiment 2 for the Spanish production tasks were in line with observations from previous studies (Section 1.4.1. and 1.4.2.). In the action naming task we found verb type to be a significant predictor of both the error rates and SOTs, with unaccusatives eliciting higher error rates than unergatives and higher SOTs than transitives and unergatives. In the sentence elicitation task, transitives were significantly more error-prone than unergatives. No effects of verb type were observed in the Spanish comprehension tasks. In Basque, we found no effects in the action naming task, however, the verb type was a significant predictor of SOTs in the sentence elicitation task, with unergatives eliciting higher SOTs than transitives. No parallel effect was found in the error rate analysis for sentence elicitation in Basque. Finally, there were no effects of verb type in any of the Basque comprehension tasks.

In the following discussion, we will first address the verb type effects found in production tasks for Spanish and Basque, while attempting to relate these findings to the observations from Experiment 1 (Section 2.2.3.1.). Then, the null results in the comprehension domain will be discussed (Section 2.2.3.2.) and followed by the Section 2.2.3.3. summarizing the limitation of Experiment 2.

2.2.3.1. Production: Action naming and sentence elicitation

When comparing the results of these two tasks in Spanish, manipulating verb type led to different effects at the single-word vs. sentence level. This finding is in accordance with previous studies (e.g., Malyutina & den Ouden, 2017; Malyutina & Zelenkova, 2020) showing differences across the two levels of linguistic representation. For example, Malyutina and Zelenkova (2020) investigated the production of verbs and sentences, evaluating both the number of arguments and canonicity of argument mapping as predictors of naming accuracy and latency in a verb naming task and of well-formedness and canonicity of produced sentences in a sentence production task. The study tested Russian speakers with fluent and non-fluent aphasia matched with neurotypical controls. Contrary to our findings, they found no effect of verb type on any of these measures for the neurotypical speakers. However, in people with both fluent and non-fluent aphasia, they reported higher error rates for unaccusatives compared to unergatives in the verb naming task and also for transitives compared to unergatives in the sentence production task. Hence, their findings in the clinical population go hand in hand with our outcomes for Spanish unimpaired speakers. In their study, Malyutina and Zelenkova suggested that the cognitive difficulty of verb processing should always be estimated in interaction with the employed task and reasoned that task dependency of argument structure complexity effects can account for varying outcomes across single-word and sentence production tasks.

Our results from neurotypical speakers in Spanish production tasks broadly point in the same direction: when the canonicity of argument mapping and the number of arguments are contrasted at the single-word level, the canonicity of argument mapping is a stronger predictor of the error rates and SOTs than the number of arguments. In other words, at the single-word level, verbs undergoing non-canonical argument mapping have a more decremental effect on verb naming latencies than verbs requiring a higher number of arguments. One explanation for this phenomenon has been provided by the *Facilitation Through Complexity Hypothesis* (Malyutina & Den Ouden, 2017; Malyutina & Zelenkova, 2020). This hypothesis suggests that a verb associated with more arguments provides richer lexical-semantic associations with various nouns. The richer semantic network can in turn partially facilitate verb retrieval, as shown in various therapeutic approaches to aphasia (e.g., VNeST: Edmonds, 2016; Webster & Gordon, 2009), and possibly override the burden of having more arguments associated with transitives. Previous evidence showing the stronger effect of non-canonical argument mapping when compared to the effect of the number of arguments at the single-word level for both unimpaired speakers and PWA also supports this notion (Luzzatti et al., 2002).

Crucially, the same mechanism does not necessarily apply at the sentence level. During sentence elicitation, the effect of non-canonical argument mapping may be overridden by the burden carried by verbs that require more arguments. A well-formed, obligatorily transitive sentence requires the lexical access to and the retrieval of at least two arguments, which generates more opportunities for errors when compared to intransitive sentences. Since participants tend to elicit more errors in transitive sentences because they have more opportunities to do so, the number of arguments in turn acts as a stronger predictor of error rates when compared to the canonicity of argument mapping at the sentence level. This explanation, supported by the findings of Malyutina and Zelenkova (2020) for speakers with aphasia, would also account for our results in neurotypical speakers in Experiment 2. Compared to the Malyutina and Zelenkova's study, which tested only 20 control participants (in addition to 40 PWA), our analyzed sample of neurotypical speakers was almost twice as large. Additionally, unlike our sentence elicitation task, their task included written verbs, which likely facilitated verb retrieval. Both of these differences might have contributed to the different outcomes of the two studies regarding the neurotypical population.

Nevertheless, in Experiment 1 we did not observe the same increase in error rates for Spanish transitives at the sentence level as we did in Experiment 2. In addition, we found higher SOTs for Spanish unaccusatives in Experiment 1, arguing that the non-canonical argument mapping of the unaccusative patient-like agents delays the onset of sentence production. Again, it is likely that task-related differences between Experiments 1 and 2 contributed to these discrepancies. For example, in the sentence production task of Experiment 1, participants were presented with a written verb, which had to be incorporated into a sentence with a semantically plausible subject and an object, if needed. In contrast, the arguments required in the sentence elicitation task of Experient 2 were all provided (although not as written but as visual probes), which might have facilitated sentence planning by narrowing the suitable argument candidates down to one or very few (e.g., *a girl*, *a woman*, *a lady*, in the case of a female subject presented as a visual probe). Unlike the sentence elicitation task in Experiment 2, the sentence production task of Experiment 1 posed sufficient demands on planning, leading to significant SOT differences between unaccusatives and unergatives. If speech latencies and planning strategies are to be evaluated, a more free-recall type of production task like the one used in Experiment 1 might be a better alternative (cf. Momma et al., 2018). On the contrary, the sentence elicitation task of Experiment 2 elicited overall higher error rates, leading to the observed transitivity effect, perhaps due to more restrictive argument recall. Hence, a sentence elicitation task with visual probes like the one used in Experiment 2 might be sufficiently restrictive and better suited when studying verb type effects on speech errors.

Moving to Basque, we found no effects of verb type in the action naming task and both the error rate and SOT patterns at the single-word level resembled those found in Spanish. However, in the sentence elicitation task, unergatives elicited significantly higher

SOTs than transitives. Moreover, there was also a prominent trend for unergatives to incur more errors compared to other verb types, although this trend was not statistically significant. These results bring partial support for our initial hypothesis and further reinforce our findings from Experiment 1, where we argued that unergatives are more processing costly in Basque due to the mismatch of their intransitive features combined with the ergative case requirements typical of transitive verbs.

Experiment 2 also enabled us to compare single-word and sentence level performance in production. The comparison of behavioral patterns in Basque further reinforces the task-dependence account of argument structure complexity effects (Malyutina & Zelenkova, 2020) that can account for our observations in Spanish. The results in Basque also suggest that ergative case assignment is a stronger predictor of argument structure complexity effects in Basque sentence production, at least when combined with the intransitive nature of unergative verbs.

To sum up, our results for Basque from Experiments 1 and 2 imply that argument structure information related to the ergative case may not need to be fully retrieved or processed when accessing verbs in isolation. Nevertheless, evidence from sentence-level tasks in both Experiments 1 and 2 suggests that case assignment significantly affects verb retrieval in the sentence context. In the general discussion (Section 3.1.2.), we will attempt to propose our account for the contribution of the ergative-case factor at the sentence level in Basque.

2.2.3.2. Comprehension: Verb-picture and sentence-picture matching

We did not find any effects of verb type on error rates or RTs when analyzing the comprehension tasks of Experiment 2. These results go in line with the outcome of

Experiment 1, where no differences were reported in the comprehension domain. Although the numeric trends found in the error rate analysis of the sentence-picture verification task across languages do support our initial hypothesis (lower performance in sentences with non-canonical argument mapping in Spanish and on unergatives and/or transitives compared to unaccusatives in Basque), these numerical trends were not statistically significant.

Upon finding no effects in the lexical decision task of Experiment 1, we argued that the discrepancy between the findings of this task and the sentence production task might be due to speech production posing higher computational demands and requiring more complex processing routines than those needed for comprehension (Section 2.1.3.1.). We also hypothesized that detecting argument complexity effects in comprehension might be more challenging because of the highly automatized processing routines involved in the lexical decision task, which often lead to at-ceiling performance. Nevertheless, in Experiment 1 we only employed one lexical-level task in comprehension and one sentence-level task in the production domain. Therefore, we were unable to tease apart the contribution of domain vs. level of linguistic representation. Experiment 2 partially helped us disentangle this dispute: the null results across both languages in both single-word and sentence-level comprehension tasks imply that argument complexity effects (at least at the behavioral level) are less likely to be detected in tasks targeting comprehension, regardless of the level of linguistic representation (lexical vs. sentence level). Similar domain specificity of verb type effects has been reported in previous studies on aphasia (Kim & Thompson, 2000) as well as for healthy speakers (McAlister et al., 2009). Crucially, this does not necessarily imply that the configuration of verbal arguments only affects production and not comprehension (indeed, even in the absence of behavioral effects, argument structure manipulations in comprehension can still be detected at the neurophysiological level, e.g., Malyutina & den Ouden, 2017; Meltzer-Asscher et al., 2015). It merely suggests that tasks targeting production are more sensitive to argument structure complexity effects at the behavioral level.

Going back to the models of speech production and comprehension (Section 1.3.), our null results in comprehension vs. verb type effects found in production support the view that the granularity of argument structure information that needs to be retrieved and processed in production vs. comprehension may differ. In other words, the same level of argument structure details that are required to produce words and sentences may not be needed in speech comprehension when interpreting verbs and their arguments.

2.2.3.3. Limitations

One of the main limitations of this study is its relatively small sample size compared to Experiment 1, for which we recruited almost twice as many participants (n = 71 vs. n = 40). It is an open question whether a larger sample size and more statistical power would enable us to detect argument structure complexity effects in tasks with otherwise prominent numeric trends across verb types. Future experiments looking into the cross-linguistic differences in relation to argument structure complexity effects would certainly benefit from a larger sample size.

Regarding the tasks used in Experiment 2, these were originally designed for Experiment 3 (i.e., for PWA). Although these tasks were subsequently tailored to the specific objectives of Experiment 2, we perhaps could have avoided some of the ceiling effects by designing a novel set of more demanding tasks, better suited to neurotypical speakers.

2.3. Experiment 3[2]

While Experiments 1 and 2 both focused on neurotypical Basque-Spanish bilinguals, Experiment 3 was set to investigate the effects of ergative case marking alongside the number of arguments and canonicity of their mapping on the verb processing in PWA. Two cases of bilingual PWA (a Spanish-English and a Basque-Spanish speaker) were recruited and their performance on the tasks used also in Experiment 2 was cross-linguistically evaluated.

2.3.1. Introduction

PWA often experience difficulties in the production of verbs. However, not all verb types are affected to the same extent (for a review, see Thompson & Meltzer-Asscher, 2014). In Section 1.4., we discussed two syntactic factors consistently reported to affect the performance of PWA in verb and sentence production: 1) the number of arguments that a verb requires and 2) the mapping of these arguments onto their thematic roles. To account for the difficulties related to verbs with more arguments and non-canonical argument mapping, the *Argument Structure Complexity Hypothesis* (ASCH; Thompson, 2003) proposed that verbs with greater argument structure complexity are more difficult for PWA to produce. The ASCH assumes this complexity increases with both the number of arguments (intransitives < transitives) and the presence of non-canonical argument mapping (unergatives < unaccusatives). It has been proposed that the disruptions in the access and retrieval of argument structure information described in serial models of

[2] This is a modified version of a Manuscript "Processing argument structure in bilingual aphasia: A cross-linguistic comparison" submitted to *Cognitive Neuropsychology* journal on October 3rd, 2023.

language production (e.g., Bock & Levelt, 1994; Levelt et al., 1999; see Section 1.3.1.) give rise to the verb impairments observed in PWA (Kim & Thompson, 2000; 2004; Thompson, 2003).

Although the ASCH was originally put forward to account for speech production deficits in agrammatic aphasia, there are studies showing parallel comprehension difficulties at the lexical (Miceli et al., 1988) and sentence level (McAllister et al., 2009, cf. Cho-Reyes & Thompson, 2012; Kim & Thompson, 2000; Thompson, 2003). The ASCH has also been utilized to explain the performance of participants with fluent and non-fluent aphasia, anomic aphasia, conduction aphasia, and primary progressive aphasia (e.g., Caley et al., 2017; Malyutina & Zelenkova, 2020; McAllister et al., 2009; Thompson et al., 2012).

To date, the ASCH has been supported by evidence from various languages including Dutch (Bastiaanse & van Zonneveld, 2005), Russian (Dragoy & Bastiaanse, 2010), Italian (Barbieri et al., 2010; Luzzatti et al., 2002), and Spanish (Martínez-Ferreiro et al., 2014; Sanchez-Alonso et al., 2011). However, it has not been comprehensively tested in PWA who speak an ergative-absolutive language like Basque. Assuming verb-specific morpho-syntactic requirements, including case assignment, are part of the argument structure information (as proposed by Bock & Levelt, 1994), the ergative case marking could be expected to differentially increase the complexity of lexical entries within those Basque verb groups that assign the ergative case. Subsequently, the higher complexity of verbs that assign the ergative case could differentially influence the performance of PWA in Basque compared to speakers of languages with nominative-accusative case alignment, like Spanish or English.

Experiment 3 was designed to investigate how the properties of three verb groups with varying AS complexity (unergatives, unaccusatives, transitives) affect the performance of two bilingual PWA: 1) a Spanish-English bilingual, speaking two languages that share argument structure properties; and 2) a Basque-Spanish bilingual, speaking two languages with different argument structure realization. The main objective of Experiment 3 was to test whether the morpho-syntactic differences imposed by ergative case assignment in Basque would lead to a decrease in performance for those verbs that assign the ergative case (i.e., unergatives and transitives), diverging from the ASCH predictions. Our second objective was to test the ASCH in Spanish and English, where the performance for the tested verb groups was not expected to differ across these two languages in line with the implied ASCH predictions. We reasoned that bilingual PWA would be an ideal population to study the hypothesized cross-linguistic differences in performance, as they allow us to investigate argument structure processing within-subject in a population with high inter-subject variability. Although the generalizability from case studies is limited, case-study design provides insight into the cross-linguistic patterns of interest while controlling for high variability resulting from a between-subject design (for a review of single-case study strengths, see Nickels et al., 2022).

2.3.1.1. Evidence from Basque and Spanish

To date, only a small number of studies have contrasted the number of arguments and/or the canonicity of their mapping in Spanish and Basque PWA. For example, a study by Sanchez-Alonso et al. (2011) conducted in Spanish monolingual PWA compared production of sentences with alternating transitives and their unaccusative counterparts via a picture-elicited sentence completion task. The unaccusatives elicited more grammatical errors than transitives, implying that Spanish PWA found sentences that include verbs with non-canonical argument mapping to be more difficult to produce compared to sentences with transitive verbs. This finding is in line with previously reported studies in different languages (e.g., Bastiaanse & van Zonneveld, 2005; Dragoy & Bastiaanse, 2010). However, Sanchez-Alonso et al. (2011) did not include unergatives and hence the full hierarchy of verbs with varying AS complexity predicted to affect performance in PWA cannot be established based on their results.

A later study by Martínez-Ferreiro et al. (2014) contrasted unergatives, unaccusatives, and alternating transitives in Spanish monolingual PWA. They tested these verb groups in action naming and picture-based sentence elicitation tasks. In addition, a picture-matching task that included unaccusative and transitive alternating verbs was also administered. Numerically higher error rates were reported for unaccusatives compared to unergatives in the production tasks, implying that when unaccusatives are directly compared to unergatives in Spanish PWA, the error rate patterns are in line with the predictions of the ASCH.

Various cross-linguistic designs have also been used to explore AS in bilingual PWA, capitalizing on cross-linguistic morpho-syntactic differences. For example, a case study in Basque-French bilingual PWA tested performance on Basque verbs and sentences with different numbers of arguments (Pourquié, 2013). This study reported increasing difficulty for Basque verbs that entail more arguments in sentence production, although it did not test the effect of ergative case marking. Extending this study to consider this issue would be of particular theoretical interest in Basque due to its ergative case morphology requirements described above.

Arantzeta et al. (2019) studied the comprehension of monolingual Spanish and bilingual Basque-Spanish PWA matched with unimpaired controls when listening to sentences in canonical (agent-theme) vs. non-canonical (theme-agent) order. Crucially, in

Basque, ergative case marks the distinction between these two conditions. Worse accuracy was reported in Basque compared to Spanish in both sentence conditions in PWA and also in the theme-agent condition in the bilingual controls. Their results suggest that the Basque-specific case morphology, which needs to be processed to achieve the accurate interpretation of sentences with varying thematic role order (i.e., the same morphology that distinguishes agents and themes of various argument structures in Basque), might hinder the comprehension of these sentences in Basque-speaking PWA as well as in healthy speakers. These cross-linguistic asymmetries are compatible with previous findings from Hanne and colleagues (2015), who reported increased cognitive demands when processing case morphology compared to number agreement, both used as cues to sentence comprehension in German-speaking PWA. Based on these findings, Hanne and colleagues speculated that the processing of case morphology might be more vulnerable to impairment in PWA than other types of morphological cues. In languages like Basque, where case morphology is used to interpret the thematic roles of sentence constituents, the disruption of the processes responsible for case morphology in both the production and comprehension domains may be especially salient in the performance of PWA.

In addition, Munarriz and colleagues (2016) also reported a differential cross-linguistic morpho-syntactic impairment for subject-relative and object-relative clauses and questions in a case study of a Basque-Spanish bilingual PWA whose performance in Basque was lower compared to Spanish in all conditions except subject questions. The increased difficulties observed in Basque imply that the specific case morphology, which is used as a cue to assign thematic roles in Basque, is not equally available to PWA compared to the morphological and word-order cues used to interpret corresponding sentence structures in Spanish. Although at the individual level these findings could be interpreted as differential cross-linguistic impairments present in the concrete cases of the bilingual PWA, they may also indicate that a brain injury impacts languages differently (Paradis, 2004) or imply that cross-linguistic differences scale with the typological distance of the contrasted languages.

2.3.1.2. The experimental design, hypotheses, and predictions

To our knowledge, no study has comprehensively tested how ergative case assignment in Basque contributes to verb-related difficulties in PWA. In addition, no study has tested the effect of ergative case marking on the performance of Basque-speaking PWA alongside another language with a nominative-accusative case alignment system.

In light of these gaps, Experiment 3 was designed to contrast two distinct language pairs: Spanish and English with an equivalent case alignment system vs. Spanish and Basque with two distinct case alignment systems. Two bilingual PWA (a Spanish-English and a Basque-Spanish bilingual), both showing similar aphasia symptoms, and a group of neurotypical bilinguals were tested on the same verb types examined in Experiments 1 and 2 (i.e., unergatives, unaccusatives, and transitives) that differ in: 1) the number of arguments, 2) canonicity of argument mapping, and 3) case assignment in Basque. Participants' performance was measured in a series of tasks focused on three levels of language representation (i.e., lexical, sentence, and connected speech) across both production and comprehension. This has not been done in previous studies in aphasia, which have focused on either a single domain or on a smaller subset of linguistic levels. The production tasks included: 1) action naming, 2) sentence elicitation, and 3) story elicitation. The tasks used to test comprehension were: 4) verb-picture verification, 5) sentence-picture verification, and 6) story-picture verification.

In this experiment, we tested a hypothesis that Basque ergative case marking required by unergatives and transitives incurs higher error rates in PWA when compared to unaccusatives which assign the absolutive case and require no overt case morphology. We expected this case marking distinction to manifest as higher error rates for Basque unergatives and/or transitives compared to unaccusatives across all tested tasks, but particularly in tasks targeting production. We attempted to assess the performance in Basque alongside Spanish and English, where the error rate patterns were expected to align with the predictions of the ASCH (Thompson, 2003). In accordance with the ASCH, higher processing demands were predicted for unaccusatives and/or transitives compared to unergatives in both English and Spanish across tasks but especially in the production domain. These higher demands would manifest as higher error rates for unaccusatives and/or transitives compared to unergatives, reflecting the difficulties associated with processing a higher number of arguments or non-canonical thematic mapping (see Table 2 in the Section 1.5.5.).

2.3.2. Methods

2.3.2.1. Participants

Two female bilingual PWA were recruited for the study: a Spanish-English bilingual (PWA1) and a Basque-Spanish bilingual (PWA2). Both PWA were highly proficient in both languages pre-onset with more spared Spanish post-onset and they were both classified as mild, non-fluent and anomic by the referring speech-language pathologists.

PWA1 was a 59-year-old, right-handed female of Puerto-Rican origin with Spanish as her native language. She immigrated to the USA when she was 13 years old, where she started acquiring and became fluent in English by the age of 15 and where she also completed her secondary school education and associate degree. At home and with her friends she spoke both Spanish and English with frequent code mixing, while using mainly English during social interactions outside her home and friendship circles. Six years prior to the experiment PWA1 suffered a left cerebrovascular accident (CVA) resulting in chronic mild, non-fluent aphasia and anomia. While she rated herself as overall highly proficient in both Spanish and English pre-onset, she self-rated her proficiency to be higher overall in Spanish post-onset (Appendix C.1.). Contrary to her self-rated evaluation, we found higher scores in English compared to Spanish when assessing her performance on a series of language tasks prior to the experiment (Section 2.3.2.3.). At the time of the data collection, she was attending speech-language therapy sessions in both Spanish and English.

PWA2 was a 21-year-old, right-handed female born in the Basque Country (Spain) with Basque as her native language. She started acquiring Spanish at the age of three in the pre-school education context and became fluent around the age of five. In her daily life she was mostly exposed to Basque in the context of her family, relatives and close friends while using Spanish in wider social interactions and in academic settings (alongside Basque) with frequent code mixing in all these settings. Four years prior to the experiment she suffered a traumatic brain injury (TBI) resulting in chronic mild, non-fluent aphasia and anomia. She rated herself as highly proficient in both Basque and Spanish pre-onset and self-reported lower proficiency in Basque post-onset (Appendix C.1.) which she attributed to a lack of speech-language therapy in Basque during the acute aphasia phase. Her self-perceived ratings aligned with our language assessment, where she scored higher in Spanish compared to Basque (Section 2.3.2.3.). At the time of the data collection, the PWA2 was attending speech-language therapy in both Basque and Spanish.

Additionally, six neurotypical, female participants were also recruited for the experiment so that each PWA was matched as closely as possible in age, education and bilingual profile with three controls (Table 11). Prior to the experiment, the bilingual profiles of all eight participants were assessed by The Language Experience and Proficiency Questionnaire: a self-rated measure of language proficiency and exposure questionnaire (LEAP-Q; Marian et al., 2007) and by a Bilingual Switching Questionnaire: a self-assessment of individual differences in language switching (BSWQ. Rodriguez-Fornells et al., 2012). Both PWA also completed an adapted version of the Communicative Effectiveness Index (CETI; Lomas et al., 1989), evaluating general communication abilities (Appendix C.1., C.2. and C.3.). All the participants gave written informed consent and the control participants were offered 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 11. Background information for PWA1, PWA2 and their controls.

Subject	Age	Sex	Years of education	Etiology	Years-post onset	Type of aphasia
Spanish-English						
PWA1	59	F	14	left CVA	6	Mild, non-fluent aphasia; anomia
C1	66	F	20	-	-	-
C2	61	F	14	-	-	-
C3	68	F	17	-	-	-
Basque-Spanish						
PWA2	22	F	15	TBI	4	Mild, non-fluent aphasia; anomia
C1	22	F	17	-	-	-
C2	22	F	17	-	-	-
C3	22	F	17	-	-	-

2.3.2.2. Stimuli

The same visual stimuli used in Experiment 2 were also utilized in Experiment 3 for Basque-Spanish participants. In addition, a set of English unergative, unaccusative, and transitive verbs was pre-selected and illustrated by the same artist as simple, colorful drawings. The drawings of verbs in English were presented to 16 speakers of a variety of English spoken in the United States (referred to as "English" throughout). The Spanish visual stimuli were presented to 16 speakers of a variety of Latin-American Spanish (referred to as "Latin-American Spanish"). Following the same categorization procedure as in Experiment 2, we selected a final set of 27 verbs (9 unergative, 9 unaccusative, and 9 transitive) for each language and their corresponding action drawings (Appendix C.4.). The pictures and verbs were further controlled for the same visual/psycholinguistic factors as in Experiment 2 (Appendix C.5.).

The same drawings were used as visual stimuli in action naming, sentence elicitation, verb-picture verification and sentence-picture verification tasks. For the story elicitation task and story-picture verification tasks, we scripted 15 short stories per language that contained the same verbs from our 27-item stimuli lists (5 stories with each verb type). Every scripted story was depicted by a series of four pictures (created by the same artist as the visual stimuli in the rest of the tasks) that were designed to elicit three target verbs of the same verb type.

The auditory stimuli used to create both congruent and incongruent trials in the comprehension tasks were recorded by two female Basque-Spanish bilinguals (also used in Experiment 2) and additionally by two male speakers (one English and one Latin-American Spanish). For details on the auditory stimuli, see Appendix C.6.

2.3.2.3. Procedure

The experiment was divided into six sessions (including two sessions for language assessment in each language), all of which were conducted online via a video-call platform. Every session lasted approximately 30 minutes with a minimal interval of two days and a maximum interval of two weeks between sessions. Every session was held in one language only, such that every participant (both PWA and six matched controls) completed three sessions in each language. The order of the languages was kept constant across participants (Appendix C.7.). Every session was led by a trained bilingual research assistant: the PWA1 and her controls were attended by an English and Latin-American Spanish speaker, while the PWA2 and her controls were attended by a Basque (using *Euskera Batua,* which is considered a standard variety of Basque) and Peninsular Spanish speaker. Additionally, 90% of the sessions were also attended by the thesis author, who monitored the consistency in following the experimental protocol across sessions. During each session, participants were asked to sit in a quiet room at their computer, equipped with a microphone and speakers or headphones. At the start of every session, we obtained participants' permission to record the video call and asked them to maximize their screen view. The experimental stimuli were delivered with the use of a share-screen feature via PowerPoint presentation mode. Every session was video-recorded and the oral responses were transcribed verbatim after each session by the research assistants in collaboration with the thesis author.

The first two sessions consisted of a language assessment in each language, which tested object naming, action naming, picture description, object-picture matching, action-picture matching and sentence-picture matching. The purpose of this assessment was to evaluate participants' general performance across both languages and to get a baseline for each PWA with regards to their verb retrieval as compared to noun retrieval performance (Appendix C.8.).

In the four remaining sessions, participants were asked to complete the six experimental tasks (see Figures 15 and 16 for examples). A fixed order of tasks (Appendix C.7.) and trials was followed and every task was preceded by oral instructions and practice items to ensure participants understood the task (see Appendix C.6. for task descriptions, instructions, trial order, randomization and scoring procedures; see Appendix C.10. for the transcriptions of responses and scoring of each PWA in the production tasks).

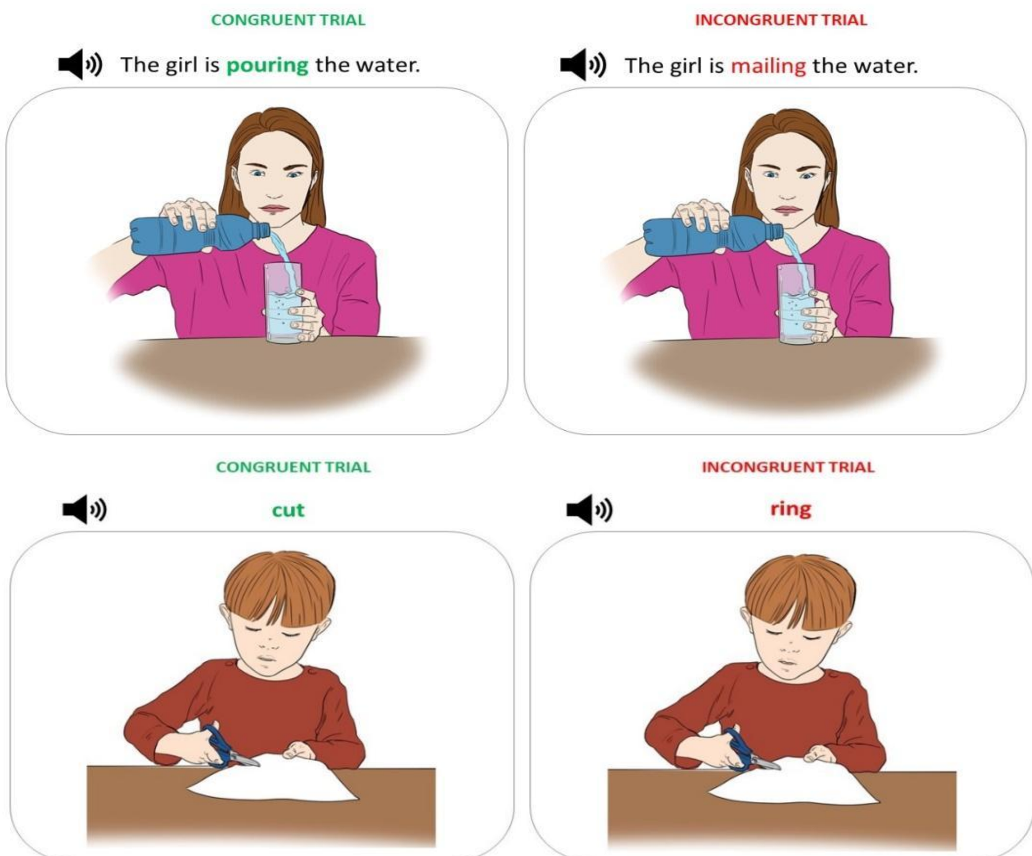


Figure 15. Examples of congruent and incongruent trials (audio transcribed into text) for the verb-picture and sentence-picture verification tasks in English. Participants were asked to indicate whether the visual stimulus matched the auditory one by providing an oral yes/no response.

Figure 16. An example of an incongruent trial (transcribed into text) for the story-picture verification task in English; every trial contained three target verbs of the same type (here *wave*, *snore* and *laugh*), Participants were asked to indicate whether everything said in the story matched the pictures by providing an oral yes/no response.

2.3.3. Results

2.3.3.1. Overall error rates: PWA and controls

We used the Crawford Bayesian methods (Crawford et al., 2011) to assess the performance of each PWA relative to controls utilizing the *crawford.test* function from the psycho package (Makowski, 2018) in R (R Core Team, 2012). As expected, the PWA committed significantly more errors compared to the controls across most of the tasks (Table 12).

To evaluate the overall performance for each PWA across levels of linguistic representation (lexical, sentence, connected speech) within each domain (production, comprehension), we plotted the percent error for each PWA and language by levels of linguistic representation for each domain separately (Figure 17). Based on visual inspection of the data, dissociations were apparent across domains and levels of linguistic representation. In the production domain, PWA2 made relatively more errors in action naming (in Basque also in sentence elicitation) than in story elicitation. In contrast, in comprehension, the error rates generally increased together with increasing complexity of linguistic representation for both PWA across languages. Although assessing dissociations across tasks and domains was not the main focus of this study, we addressed this incidental finding and its theoretical implications in the discussion (Section 2.3.3.4.).

Table 12. Error count and percent error for PWA1 and PWA2, the mean error count and percent error for controls, SD*,* the results of the Crawford analysis reported for each language (Z score; the percent (%) of the group with higher error count than the PWA; the confidence interval (= CI)); *p*-values with asterisks indicate statistical significance; note that tasks with SD = 0 could not be evaluated with this method.

	PWA1		**Controls**				**Statistical comparison**	
Spanish	*errors*	*percent error*	*errors (mean)*	*percent error*	*SD*	*Z*	*The score higher than % of the group (CI)*	*p-value*
action naming	3 / 27	11.11 %	0 / 27	0.00 %	0.00	-	-	-
sentence elicitation	0 / 27	0.00 %	0 / 27	0.00 %	0.00	-	-	-
story elicitation	6 / 45	13.33 %	0.33 / 45	0.73 %	0.58	9.78	99.36 ([0.0 - 0.02])	.006*
verb-picture verification	2 / 54	3.70 %	0 / 54	0.00 %	0.00	-	-	-
sentence-picture verification	3 / 54	5.56 %	1 / 54	1.85 %	0.00	-	-	-
story-picture verification	8 / 30	26.67 %	0.33 / 30	1.10 %	0.58	13.22	99.62 ([0.0 - 1.77e-03])	.004*
total	**22 / 237**	**9.28 %**	**1.66 / 237**	**0.70 %**	**1.15**	**17.68**	**99.82 ([0.0 - 3.70e-05])**	**.002***
English								
action naming	6 / 27	22.22 %	0.66 / 27	2.44 %	1.67	4.63	97.28 ([0.0 - 0.18])	.027*
sentence elicitation	3 / 27	11.11 %	0 / 27	0.00 %	0.00	-	-	-
story elicitation	7 / 45	15.56 %	0.33 / 45	0.73 %	0.58	11.50	99.59 ([0.0 - 4.86e-03])	.004*
verb-picture verification	3 / 54	5.56 %	0.33 / 54	0.61 %	0.58	4.60	97.34 ([0.0 - 0.19])	.026*
sentence-picture verification	5 / 54	9.26 %	0 / 54	0.00 %	0.00	-	-	-
story-picture verification	11 / 30	36.67 %	1 / 30	3.33 %	0.00	-	-	-
total	**35 /237**	**14.77 %**	**2.33 / 237**	**0.98%**	**1.53**	**21.35**	**99.86 ([0.0 - 4.81e-07])**	**.001***
	PWA2		**Controls**			**Statistical comparison**		
Spanish	*errors*	*percent error*	*errors (mean)*	*percent error*	*SD*	*Z*	*The score higher than % of the group (CI)*	*p-value*
action naming	5 / 27	18.52 %	0 / 27	0.00 %	0.00	-	-	-
sentence elicitation	3 / 27	11.11 %	0 / 27	0.00 %	0.00	-	-	-
story elicitation	4 / 45	8.89 %	0.33 / 45	0.73 %	0.58	6.33	98.56 ([0.0 - 0.09])	.014*
verb-picture verification	0 / 54	0.00 %	0 / 54	0.00 %	0.00	-	-	-
sentence-picture verification	0 / 54	0.00 %	0.33 / 54	0.61 %	0.58	-0.57	71.94 ([0.06 - 0.50])	.281
story-picture verification	1 / 30	3.33 %	0.33 / 30	1.10 %	0.58	1.16	80.99 ([1.96e-05 - 0.46])	.190
total	**13 / 237**	**5.49 %**	**0.99 / 237**	**0.42 %**	**1.00**	**12.00**	**99.54 ([0.0 - 4.33e-03])**	**.005***
Basque								
action naming	7 / 27	25.93 %	0.33 / 27	1.22 %	0.58	11.50	99.55 ([0.0 - 5.06e-03])	.005*
sentence elicitation	7 / 27	25.93 %	0 / 27	0.00 %	0.00	-	-	-
story elicitation	3 / 45	6.67 %	0.66 / 45	1.47 %	1.15	2.03	89.64 ([1.10e-11 - 0.40])	.104
verb-picture verification	1 / 54	1.85 %	0.33 / 54	0.61 %	0.58	1.16	81.30 ([4.43e-06 - 0.46])	.187
sentence-picture verification	1 / 54	1.85 %	2 / 54	3.70 %	3.46	-0.29	68.34 ([0.10 - 0.50])	.317
story-picture verification	4 / 30	13.33 %	1.33 / 30	4.43 %	0.58	4.60	97.33 ([0.00 - 0.18])	.027*
total	**23 / 237**	**9.70 %**	**4.33 / 237**	**1.83 %**	**4.62**	**3.97**	**96.43 ([0.00 - 0.23])**	**.036***

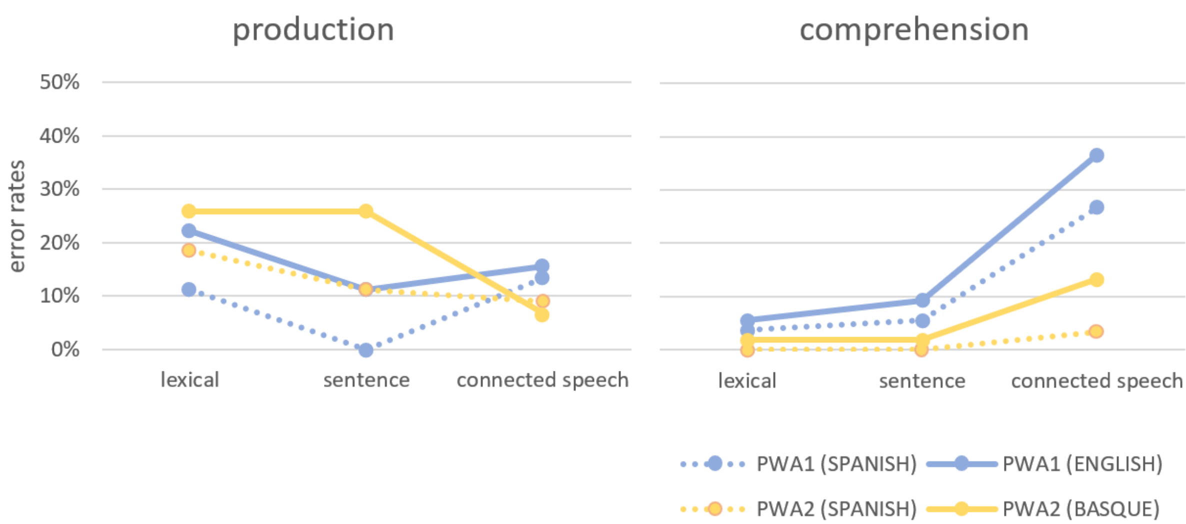


Figure 17. Percent error rates elicited by each PWA in both languages and plotted for each level of linguistic representation (lexical, sentence and connected speech) in both domains.

2.3.3.2. Error rates by verb type

To assess performance on the three verb types of interest for each PWA, we calculated the error counts and the percent error for each verb type separately across all tasks and languages (Table 13).

Table 13. Error counts and percent error by verb type reported for each PWA and language.

		UNERG	**UNACC**	**TRANS**	**UNERG**	**UNACC**	**TRANS**
		error counts (percent error)			*error counts (percent error)*		
PWA1	items	**SPANISH**			**ENGLISH**		
action naming	27	1 (3.70)	1 (3.70)	1 (3.70)	1 (3.70)	4 (14.81)	1 (3.70)
sentence elicitation	27	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	2 (7.41)	1 (3.70)
story elicitation	45	1 (2.22)	3 (6.67)	2 (4.44)	1 (2.22)	4 (8.89)	2 (4.44)
verb-picture verification	54	1 (1.85)	0 (0.00)	1 (1.85)	1 (1.85)	1 (1.85)	1 (1.85)
sentence-picture verification	54	0 (0.00)	2 (3.70)	1 (1.85)	1 (1.85)	3 (5.56)	1 (1.85)
story-picture verification	30	3 (10.00)	4 (13.33)	3 (3.33)	5 (16.67)	2 (6.67)	4 (13.33)
Total	**237**	**6 (2.53)**	**10 (4.22)**	**8 (3.38)**	**9 (3.80)**	**16 (6.75)**	**10 (4.22)**
PWA2		**SPANISH**			**BASQUE**		
action naming	27	2 (7.41)	1 (3.70)	2 (7.41)	1 (3.70)	4 (14.81)	2 (7.41)
sentence elicitation	27	1 (3.70)	1 (3.70)	1 (3.70)	1 (3.70)	2 (7.41)	4 (14.81)
story elicitation	45	1 (2.22)	1 (2.22)	2 (4.44)	0 (0.00)	1 (2.22)	2 (4.44)
verb-picture verification	54	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (1.85)
sentence-picture verification	54	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (1.85)
story-picture verification	30	1 (3.30)	0 (0.00)	0 (0.00)	2 (6.67)	1 (3.33)	1 (3.33)
Total	**237**	**5 (2.11)**	**3 (1.27)**	**5 (2.11)**	**4 (1.69)**	**8 (3.38)**	**11 (4.64)**

The total error rates across tasks showed that PWA1 made overall slightly more errors for unaccusatives compared to the other two verb types in both languages, although this difference was more prominent in English. In contrast, PWA2 made overall more errors for unergatives and transitives compared to unaccusatives in Spanish, while in Basque, transitives elicited higher error rates than unaccusatives and those were more prone to error than unergatives (Figure 18).

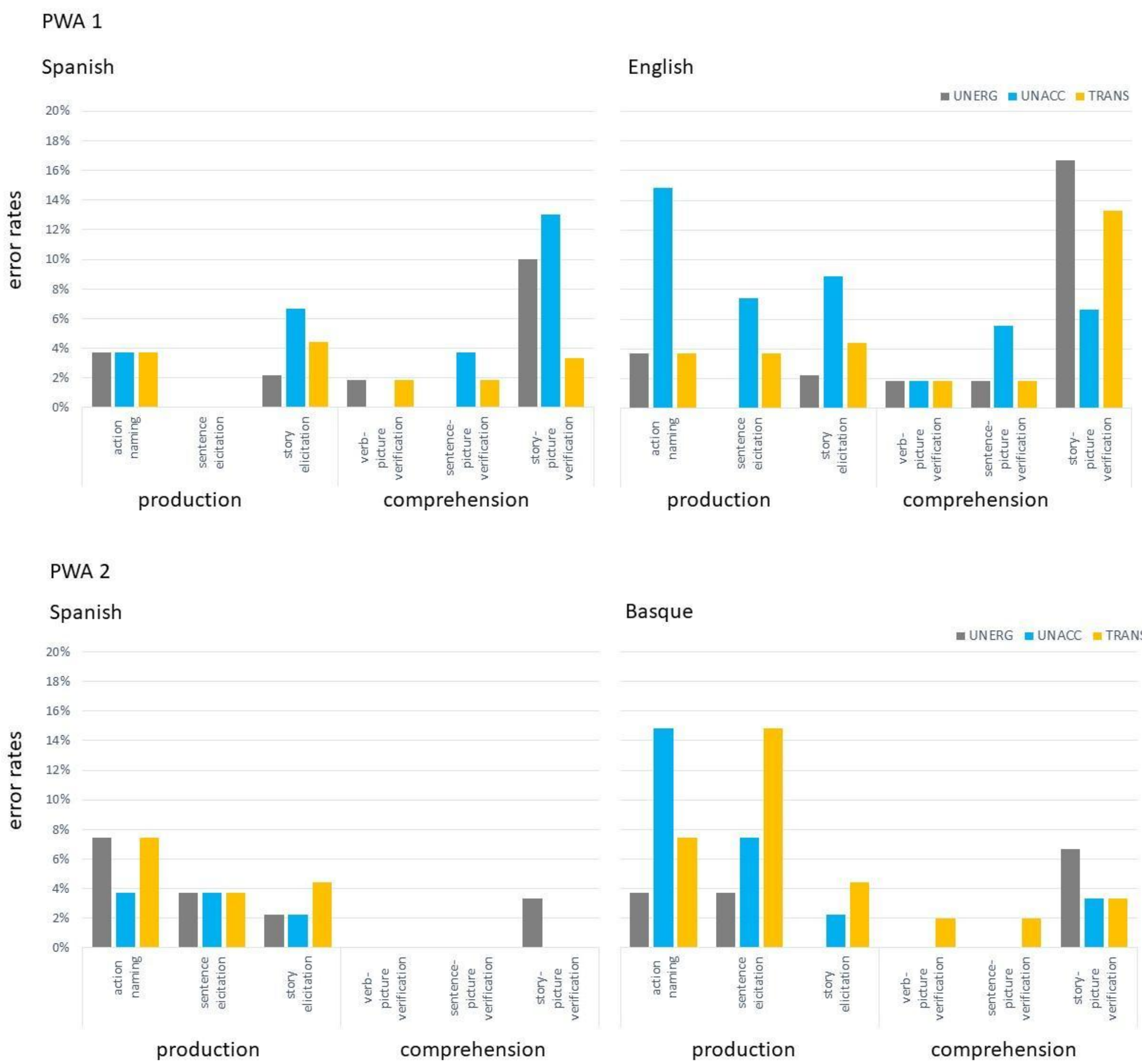
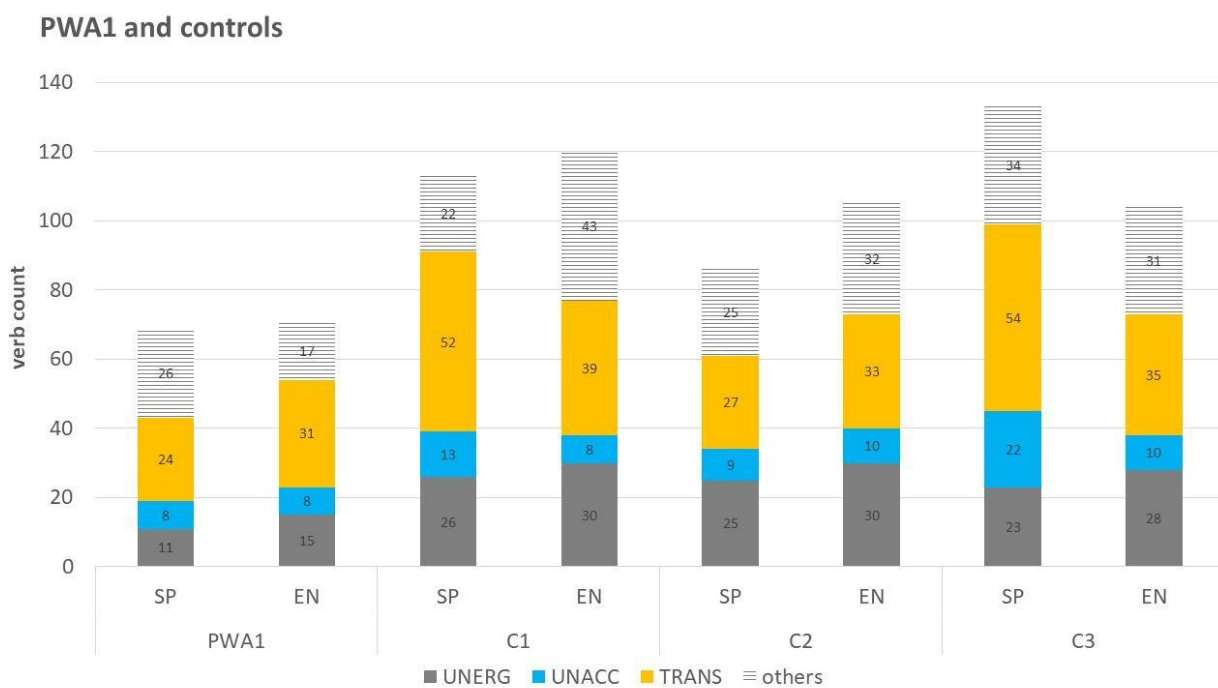


Figure 18. Percent error rates visualized for each verb type, PWA, language and task.

In addition to analyzing error rates for the three verb types, we also conducted an exploratory analysis within the story elicitation task where we compared the proportions of verb types elicited from each PWA relative to controls. Within this analysis, the number of verbs produced during the story elicitation task was counted for each PWA and control in each language separately. Every produced verb was categorized as unergative, unaccusative, transitive or "others" (a category which included copulas, e.g., *is*, *seems*, existential *be*, or empty subject structures, e.g., *there is, there are*). Finally, the verb counts produced by PWA were statistically compared to the mean counts produced by the controls using the chi-square (χ^2) test.

PWA1 produced fewer verbs relative to the mean verb count produced by her controls in both Spanish and English (Figure19). Nevertheless, the proportion of the various verb types produced by PWA1 was statistically comparable to the mean of her controls in both Spanish ($\chi^2 = 3.81$, $p = .28$) and English ($\chi^2 = 3.36$, $p = .34$).

In contrast, PWA2 produced a comparable total number of verbs as her controls in both Spanish and Basque (Figure 19). In Spanish, the proportion of the various verb types did not differ across PWA2 and her control group ($\chi^2 = 5.76$, $p = .12$). However, we observed differences in verb type proportions across these two groups in Basque ($\chi^2 = 27.57$, $p < .001$). A post-hoc test using adjusted standardized residuals (Agresti, 2013) with *z* criteria adjusted by Bonferroni correction for multiple comparisons was carried out to determine which specific verb types were responsible for this difference. The results showed that PWA2 produced significantly fewer unaccusatives (*adj. res*. = -4.41; < *z* criteria -2.73) and more verbs categorized as others, i.e., copulas, existential and empty subject structures (*adj. res.* = 3.95; > *z* criteria 2.73) than her controls in Basque (Appendix C.9.).



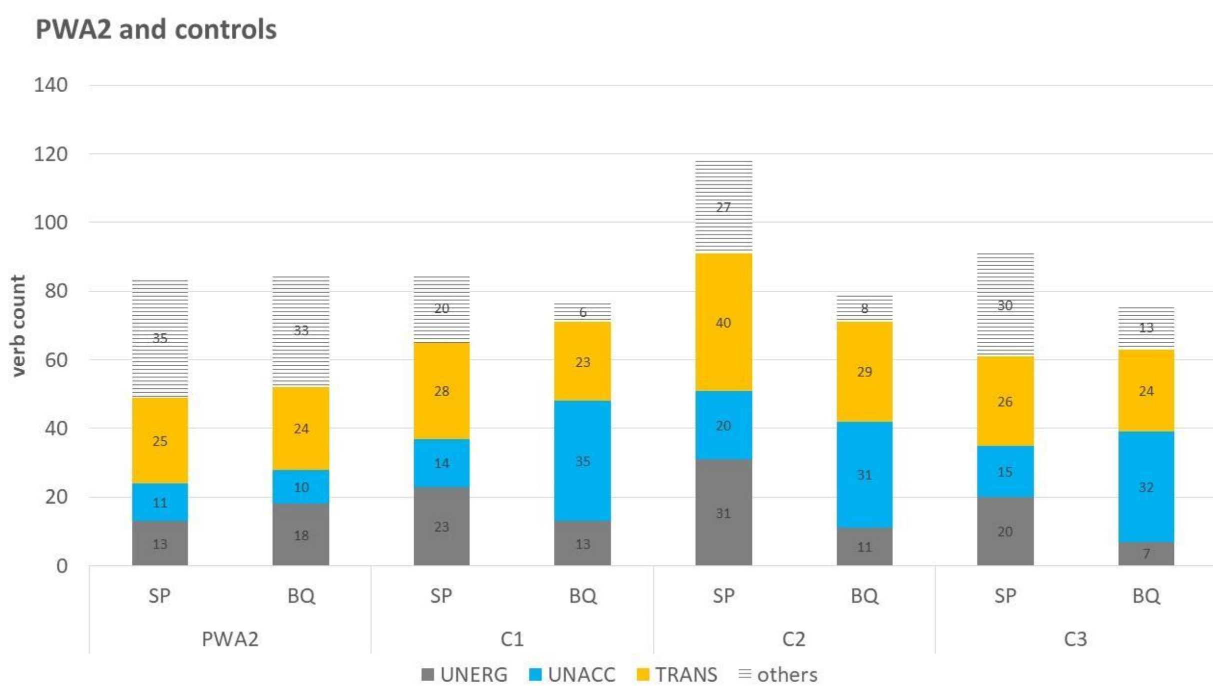


Figure 19. Proportions of different verb types (others = copulas and empty subject structures) produced by PWA1, PWA2 and their corresponding controls (C1, C2, C3) during the story elicitation task in Spanish (SP), English (EN) and Basque (BQ).

2.3.4. Discussion

In Experiment 3, two bilingual PWA (PWA1: Spanish-English; PWA2: Basque-Spanish) were tested in both of their languages in production and comprehension of unergative, unaccusative and transitive verbs across tasks targeting lexical, sentence and connected speech levels of linguistic representation. Different performance was predicted for Basque vs. Spanish and English due to the different ways in which these languages encode the verbal argument structure. In Basque, we predicted higher error rates for unergative and/or transitive verbs, hypothesizing that their ergative case assignment and case marking requirements would incur higher processing costs. In contrast, higher error rates were predicted for unaccusative and/or transitive verbs in Spanish and English in accordance with the ASCH (Thompson, 2003). While PWA1 demonstrated error rates consistent with the ASCH in both Spanish and English, the results of PWA2 were less straightforward and did not directly support our predictions.

First, we briefly address the performance of both PWA relative to their controls (Section 2.3.4.1.). Second, we separately discuss the error rates for each PWA, language and verb type as well as the proportion of different verb types produced during the story-elicitation task (Sections 2.3.4.2. and 2.3.4.3.). Finally, we address the overall error patterns, their dissociations across tasks (Section 2.3.4.4.) and limitations of Experiment 3 (Section 2.3.4.5.)

2.3.4.1. PWA compared to controls

As expected, significantly higher error rates were observed for both PWA relative to the group means across all languages, indicating that the error rates observed in PWA could be largely attributed to their language impairment associated with aphasia. Because both PWA were closely matched to their controls in terms of age, education, sex, bilingual histories and competencies, it is unlikely that the lower performance of both PWA observed in our study resulted from factors generally associated with bilingualism such as more effortful lexical retrieval (e.g., Gollan et al., 2005; Ivanova & Costa, 2008) or lower verbal fluency related to one or both of their languages (e.g., Bialystok et al., 2008; Sandoval et al., 2010).

2.3.4.2. PWA1: Error rates by verb type

Based on the ASCH (Thompson, 2003), we predicted higher error rates for unaccusatives and/or transitives compared to unergatives for PWA1 in both Spanish and English and these higher error rates were expected specifically in the production domain. The results of PWA1 in both Spanish and English mostly align with these predictions.

In Spanish, PWA1 showed overall higher error rates when presented with unaccusatives across both production and comprehension, even though the ASCH predicts the unaccusative disadvantage specifically for the production domain. This trend, however, is in line with previous findings reporting impairments in comprehension of unaccusative sentences in mild, fluent and non-fluent PWA (McAllister et al., 2009). Interestingly, McAllister and colleagues found no correlation between the effect of argument structure complexity in production vs. comprehension tasks, suggesting that although argument structure complexity may affect language processing in both domains, it influences each domain (or each specific task) in different ways.

In English, PWA1 showed overall higher error rates for unaccusatives compared to transitives and unergatives in the production domain, as predicted by the ASCH. These results are consistent with her performance in Spanish, suggesting that argument structure complexity affects both languages of PWA1 in a parallel fashion. In the comprehension domain however, this overall pattern was not as clear, mainly due to her poor performance on the story-picture verification task in English.

Apart from the disadvantage for unaccusatives, we also observed increased error rates for transitives compared to unergatives across several tasks in both languages of PWA1. Indeed, transitives, together with unaccusatives, were predicted to incur more errors due to a higher number of arguments. However, it has previously been shown that unaccusatives tend to be more problematic than transitives, implying that the effect of non-canonical argument mapping can outweigh the effect caused by a higher number of arguments (e.g., Bastiaanse & van Zonneveld, 2005; Dragoy & Bastiaanse, 2010; Sanchez-Alonso et al., 2011) and the results of PWA1 are generally in line with this evidence. Nevertheless, in previous studies contrasting verbs with different numbers of arguments in PWA, the effect predicted by the ASCH seems to be more consistently present when contrasting ditransitives vs. intransitives and transitives, with no significant difference reported between intransitives and transitives (e.g., Cho-Reyes & Thompson, 2012; Kim & Thompson 2000; 2004). Ditransitives are a very small, semantically highly related category of verbs, typically involving a subject, an object and a recipient. This group of verbs is difficult to match in frequency and length to the other verb groups we used in our study, which is why we did not incorporate three-argument verbs into our stimuli. A more comprehensive evaluation of the effect of increasing the number of arguments on performance in PWA vs. that of non-canonical argument mapping would require designs that also include a group of ditransitive verbs.

On analyzing the story elicitation task, we observed that PWA1 produced overall fewer verbs compared to controls in both languages, a finding supported by previous studies (e.g., Edwards & Bastiaanse, 1998; Rossi & Bastiaanse, 2008; Saffran et al., 1989; Thompson et al., 1995). However, there were no significant differences in the proportions of verb types PWA1 produced compared to controls, which is also in line with previous findings (e.g., Thompson, 2003). This implies that even though PWA1 shows impoverished verb production in connected speech, this is not affecting any specific verb type to a greater extent than would be expected for neurotypical speakers.

To sum up, PWA1 performed in accordance with the ASCH predictions, showing higher error rates for unaccusatives in both English and Spanish, arguably due to their non-canonical argument mapping. This tendency was observed across both domains, although, as expected, more prominent in production. Additionally, she made more errors with transitives compared to unergatives, which could also be expected based on results from previous studies specifically contrasting these two verb types. In connected speech, she used overall fewer verbs than controls, although she produced comparable proportions of each verb type.

2.3.4.3. PWA2: Error rates by verb type

Based on the ASCH (Thompson, 2003), we predicted higher error rates for unaccusatives and/or transitives compared to unergatives for PWA2 in Spanish and these were specifically expected in the production domain. Considering the Basque-specific case marking properties, higher error rates were predicted for unergatives and/or transitives compared to unaccusatives in Basque.

In Spanish, PWA2 made few errors in production tasks and she also showed at-ceiling performance in the comprehension domain, exhibiting no difference from the group mean in the verb- and sentence-picture verification tasks. Hence, it is difficult to draw any firm conclusion with respect to the ASCH based on her performance in Spanish.

In Basque, PWA2 showed overall higher error rates for transitives across production and comprehension, which could possibly be interpreted under the ASCH as arising from the higher number of arguments that transitives require. An alternative explanation for her worse performance on transitives might be a combination of Basque-specific ergative case marking and the higher number of arguments that transitives require. Due to these two factors, Basque transitives could be considered the most complex verb group, with increased processing demands, especially at the sentence level, where ergative case requirements have to be overtly met to form a grammatical sentence. Indeed, the performance of PWA2 is in line with previous findings from Basque (Pourquié, 2013), which suggest that verbs with a higher number of arguments (transitive and ditransitive) may be more difficult for PWA precisely at the sentence level, but not necessarily at the lexical level. It has previously been argued that processing disadvantages may be specific to the sentence level for verbs with complex argument structure (Malyutina & den Ouden, 2017; Malyutina & Zelenkova, 2020). As discussed earlier (Section 2.2.3.1.), Malyutina and Zelenkova proposed that lexical access to verbs can be actually facilitated by a greater number of arguments, assuming that additional arguments may provide richer lexical-semantic associations and additional routes of verb access. However, this advantage may only be available at the lexical level and disappear at the sentence level, being overridden by additional morpho-syntactic requirements imposed by transitive verbs (Malyutina & Zelenkova, 2020).

Regarding the analysis of connected speech, in contrast to PWA1, PWA2 produced a comparable number of verbs during the story elicitation task in both languages relative to controls. Similar results have previously been reported in both anomic and agrammatic aphasia (e.g., Bastiaanse & Jonkers, 1998; Luzzatti et al., 2006) or when analyzing word counts produced by post-TBI participants in narrative samples during picture description (King et al., 2006). PWA2 also produced comparable proportions of different verb types in Spanish, although not in Basque. In Basque, she produced significantly fewer unaccusatives and significantly more copulas, e.g., *izoztuta* ***dago*** / *(he)* ***is*** *frozen*, existential or locational expressions, e.g., *mendiak* ***daude*** / *(they)* ***are*** *in the mountains*, and empty subject structures, e.g., *gizon bat* ***dago*** / *there* ***is*** *a man*, compared to controls. This and similar phenomena, i.e., higher numbers of copulas, modals, semantically "light" verbs (e.g., *be*, *get*, *do*) or overall lower verb diversity produced by PWA in connected speech were reported in previous studies (e.g., Bastiaanse & Jonkers, 1998; Berndt et al., 1997a; Kegl, 1995). Moreover, post-TBI aphasia has been previously associated with semantically less complex narrative and high frequency of circumlocutions and paraphrasing (e.g., Hagen, 1984; Kong, 2022). Bastiaanse and Jonkers (1998) argued that although PWA generally produce as many verbs as controls in spontaneous speech, these verbs express less lexical content, as evident from the overall lower verb diversity in narratives. Based on the higher proportion of semantically "light" compared to "heavy" verbs in narrative samples of PWA, Berndt and colleagues (1997a) argued that semantically "light" verbs may be activated by default as a part of a syntactic frame, when semantic activation from the message level fails to select an alternative, semantically richer verb lemma (e.g., *exist*, *receive*, *prepare*). Similarly, Kegl (1995) suggested that copulas may be used by PWA with impaired lexical access as a circumlocution to replace inaccessible verbs.

In line with these authors, we interpret the lower proportions of unaccusatives and higher proportion of copulas, existential and empty subject structures in the Basque narrative samples of PWA2 as resulting from higher frequency of semantically "lighter" verbs like *egon* or *izan* / *to be* and their tendency to be part of various fixed expressions in Basque, which might facilitate their use in connected speech. The prevalence of such grammaticalized verbs in the connected speech of PWA2 may also account for the lack of unaccusatives in her narratives: she compensates for her word finding impairment, especially prominent in unaccusatives (evident from her high error rates for Basque unaccusatives in action naming) by using more functional lexical items, that are more readily available for retrieval. One example of this strategy was the substitution of the concrete, unaccusative verb *izoztu* / *freeze* with the copular expression *izoztuta dago* / *was frozen* (Appendix C.10.).

Overall, the results of PWA2 are rather mixed with no clear pattern towards a disadvantage for specific verb type(s) which leaves our findings open to various interpretations. Perhaps due to overall good performance of PWA2, we did not find straightforward support for our hypothesis predicting higher error rates associated with ergative case assignment in Basque. Higher error rates for transitives in Basque could potentially be explained with regards to their ergative case marking combined with a higher number of arguments. However, these error rate patterns are also consistent with the ASCH, which predicts greater difficulty with two-argument verbs, while making no specific claims with respect to grammatical case and/or morpho-syntactic requirements.

2.3.4.4. Dissociation between domains and levels of linguistic representation

When visually inspecting the error rates across tasks, we noticed interesting dissociation patterns calling for further evaluation. In production, PWA2 was more error-prone at lower levels of linguistic representation (i.e., lexical and sentence level) as manifested by higher error rates in action naming (in Basque also in sentence elicitation) while her performance improved at connected speech level with generally lower error rates in the story elicitation task. In comprehension, both PWA1 and PWA2 performed better at the lexical and sentence level, and their performance decreased with increasing complexity of linguistic input as evident from higher error rates during the story-picture verification task. We address these incidental findings in the following two sections, focusing separately on production and comprehension.

2.3.4.4.1. The dissociations in production

The dissociation in word finding difficulties across levels of linguistic representation has been reported by numerous studies to date (see Kavé & Goral, 2017 for a review). For example, PWA are often more error-prone and/or retrieve fewer items when naming isolated words compared to retrieving words in connected speech (e.g., Breen & Warrington, 1994; Crutch & Warrington, 2003; Hadar et al., 1987; Mayer & Murray, 2003; Pashek & Tompkins, 2002; Williams & Canter, 1982; Zingeser & Berndt, 1988).

In our experiment, the dissociation between naming in isolation and in connected speech cannot be entirely explained by the differences in task-related constraints. Undoubtedly, participants were more restricted in action naming, when instructed to use a specific verb, than in the story elicitation task, where they had more freedom to sculpt the narrative by circumscribing actions or to shift their focus to those story segments they found easier to describe. However, both PWA struggled to name certain items in isolation while producing the same items in sentences and connected speech. For example, during the action naming task, PWA1 could not name the verbs *rot* in English or *secar* (to dry) in Spanish and PWA2 could not retrieve the verbs *sonar* (to ring) in Spanish or *urtu* (to melt) in Basque. Yet they both produced these items in sentence and connected speech contexts. People with anomia have been reported to struggle when naming isolated verbs while using these in connected speech (e.g., Hadar et al., 1987; Williams & Canter, 1982). This inconsistent performance on specific lexical items across tasks cannot be explained by simply circumscribing inaccessible words during sentence and connected speech tasks.

One possible explanation for such discrepancy could be provided by contextual effects, i.e., speech production in sentences and connected speech both require discourse planning and prosodic processes and these processes, in addition to the sentence context, can actually aid word retrieval (Pashek & Tompkins, 2002). For example, sentence planning may involve higher order syntactic processes that support lexical retrieval by facilitating selection of phonological representations (Zingeser & Berndt; 1988). Although such an explanation would be problematic to accommodate under the assumptions of a strictly serial models of production (e.g., Bock & Levelt, 1994) where initial stages of lexical selection and functional assignment are unaffected by later stages, it could perhaps be explained assuming independent access to lemma and lexeme in aphasia (Caramazza, 1997; see Section 3.2.1. for further discussion).

However, not all PWA show facilitative context effects. Some case studies found superior lexical retrieval in naming compared to verb retrieval in sentences or in connected speech (e.g., Manning & Warrington, 1996; Robinson et al., 1998; Schwartz & Hodgson, 2002; Williams & Canter, 1982; Wilshire & McCarthy, 2002). Such dissociation tends to co-occur with more anterior brain damage, e.g., in Broca's aphasia (Williams & Canter, 1982). Other studies have reported PWA successfully retrieving single verbs while failing to use them with an appropriate argument structure (Barbieri et al., 2010; Webster et al., 2004) or in naming to definition (Zingeser & Berndt, 1990). These opposing patterns could reflect opposing underlying impairments: superior performance in action naming could arise from an intact access to the verb lemma and its argument structure information alongside impaired subsequent processes related to grammatical encoding. In contrast, superior performance at sentence and connected speech levels, as observed in our study, could be due to the opposite pattern of impaired and spared processing abilities. All in all, PWA do not seem to equally benefit from contextual information when retrieving lexical items for production. Previous failed attempts to find a clear relationship between the scores on action naming and the number/diversity of verbs used in connected speech imply that naming abilities may not be a good predictor of verb production in the connected speech of PWA and vice versa (e.g., Bastiaanse & Jonkers, 1998; Fergadiotis & Wright, 2016; Mayer & Murray, 2003; Williams & Canter, 1987).

2.3.4.4.2. The dissociations in comprehension

The PWAs' generally good comprehension skills were reflected in their at-ceiling performance on the verb-picture verification task, with only a slight decrease in performance during the sentence-picture verification task in PWA1, indicating well preserved comprehension at lexical and sentence levels. This finding was expected and in line with participants' generally good comprehension skills. Regarding verb comprehension at the lexical level, people with anomia have been reported to struggle when naming verbs while at the same time showing good verb comprehension (e.g., Cho-Reyes & Thompson, 2012) and our results are in line with these findings. Regarding the sentence level, prior evidence demonstrated difficulties in the comprehension of non-canonical sentences with generally well-preserved canonical sentence comprehension in people with anomia and various other aphasia types (e.g., Caramazza & Zurif, 1976; see also Caplan et al., 2007;

Cho-Reyes & Thompson, 2012). Although we tested only canonical sentences, unaccusative verbs require non-canonical argument mapping, which may explain the slightly higher error rates elicited by PWA1 for unaccusatives during sentence-picture verification.

In contrast, comprehension beyond the sentence level was significantly more demanding for both PWA (but not control participants). This impaired ability to detect incongruent verbs in the auditorily presented stories contrasted with their ability to understand the research assistants' spoken language, as indicated by their interactions during the experiment. Previous studies have suggested that PWA may follow conversation well but perform poorly on more formal comprehension tests due to the lack of communicative intent (Waller & Darley, 1978) which could perhaps explain the lower performance on this task. However, our findings could also indicate that seemingly good comprehension performance in daily interactions or in response to simple requests may mask more profound, underlying comprehension difficulties in PWA.

The comprehension impairments for specific words in narratives may reflect compromised processing strategies in PWA. A model of text comprehension proposed by Kintsch and van Dijk (1978) distinguishes between two processes involved in text comprehension: *micro-operations* consist of bottom-up processes involved in fine-grained analysis of the linguistic input, while *macro-operations* substantiate a top-down search for global coherence, imposed by the listener on the linguistic input to extract its main ideas. During macro-operations, the meaning of individual words and sentences forming the linguistic input may even be disregarded altogether and only the global idea is retained. In line with this model, past studies on sentence comprehension in aphasia suggest that PWA rely on perceptual information, on information derived from individual items, or on basic argument structure information rather than on more fine-grained linguistic analysis, which may lead them to sometimes plausible but not always correct text interpretations (e.g., Blumstein et al., 1983; Caramazza & Zurif, 1976; Schwartz et al., 1980). Based on observations from text comprehension in aphasia, Huber (1990) suggested that PWA may be overly reliant on macro-processing, while disregarding (or perhaps not being able to properly incorporate) the micro-structural analysis of speech, which can lead them to confusions regarding people, events and situations present in the linguistic input. However, PWA can still get by with this strategy, provided these confusions do not contradict the main ideas in the text. Hence, one plausible explanation for the poor performance of PWA on the story-picture verification task (especially prominent for PWA1) is the disproportional reliance on the macro-structural input analysis during comprehension of connected speech. If this were the case, disregarding some of the more detailed linguistic input (e.g., specific verbs) due to a lesser involvement in micro-processing, would be responsible for her difficulties in detecting incongruent items.

In view of our findings, we argue that comprehensive clinical assessment as well as experimental studies focused on comprehension in aphasia should not be limited to testing words and sentences in isolation, because this practice may prevent us from detecting and accurately assessing the real extent of comprehension difficulties in PWA. Such difficulties may hinder PWA from fully understanding spoken language in more complex verbal interactions. Tools such as the *Discourse Comprehension Test* (Brookshire & Nicholas, 1993) should be used for comprehensive assessment of auditory comprehension of connected speech in PWA and it is important to develop similar tools in as many languages as possible.

2.3.4.5. Limitations

The most obvious limitation of this study is the small sample size: the results from one person per language pair cannot be generalized to the total population of bilingual PWA. Data from additional bilingual participants will help determine whether the findings reported here are representative of the investigated languages.

A second limitation of this study is related to the etiologies of the two tested PWA. While PWA1's language impairments followed a left CVA, PWA2 suffered from language impairments induced by TBI, which often leads to diffuse brain damage (i.e., involving more scattered lesion sites) and results in different aphasia patterns from those typically observed as a consequence of CVA. It is possible that the performance of PWA2 on processing various dimensions of argument structure complexity diverged from what we would expect as a result of CVA—a condition more typically studied in linguistic aphasiology. It has been argued that language impairments following TBI need to be studied in the context of wider memory and general cognitive deficits that are manifested as well as language impairment, whereas in PWA induced by CVA, memory and general cognitive functions are less likely to be affected (e.g., Hinchliffe et al., 1998; Holland, 1982). Furthermore, impairments in working memory associated with TBI have previously been reported to adversely affect syntactic processing (e.g., Turkstra & Holland, 1998) or narrative discourse (e.g., Chapman et. al., 2006; Youse & Coelho, 2005). Additionally, we tested PWA2's general cognitive functions for possible impairments that could have affected her language performance, and found no evidence of such impairments (Appendix C.11.). Unfortunately, having no access to detailed medical records of PWA2, we can merely speculate about the focality of her brain damage. Hence, it is possible that PWA2 acquired some unusual language impairment patterns that prevent us from being able to derive any firm conclusions in relation to Basque in PWA following CVA. More cases of Basque bilinguals with different types of aphasia should be assessed to comprehensively evaluate our hypothesis for Basque speaking PWA.

Finally, a potential influence of repeated exposure to the same target stimuli across tasks in our experiment should be considered when interpreting the results of this experiment. Although the action naming and sentence elicitation tasks were never conducted on the same day, it is possible that repeated exposure to the same items, for example auditory exposure during comprehension tasks, may have primed some of the correct responses in sentence and story elicitation tasks in the later session. There were also instances in which PWA retrieved an item during action naming and sentence elicitation but failed to retrieve the same item in story elicitation context. These instances could have possibly arisen from more complex visual stimuli used for the story elicitation task as compared to action naming and sentence elicitation.

Chapter III. General Discussion

The present thesis investigates the influence of ergative case markings on argument structure complexity effects in both neurotypical Basque-Spanish bilinguals and bilingual PWA. The processing costs associated with the ergative case, which is assigned by unergative and transitive but not unaccusative verbs in Basque, was evaluated in parallel to Spanish and English, nominative-accusative languages that do not use case morphology to mark different types of verb argument structure. Three experiments were conducted to test our predictions that ergative case assignment would inflict higher processing costs on those Basque verb types that require ergative case marking (i.e., unergatives and/or transitives) as compared to those that assign absolutive case and require no overt case inflection (i.e., unaccusatives). In contrast, Spanish and English were both expected to elicit higher processing costs for transitives and/or unaccusatives due to the higher number of arguments and non-canonical argument mapping, respectively.

The results of Experiments 1 and 2, which targeted neurotypical Basque-Spanish bilinguals, partially support our hypothesis: unaccusatives incur higher processing costs in Spanish, while unergatives are more costly in Basque. The differential argument structure complexity effects found in neurotypical speakers are further discussed in Section 3.1. The results of Experiment 3, which tested two bilingual cases of PWA, are less straightforward. While the Spanish-English bilingual PWA shows similar unaccusativity effects found in neurotypical adults, the performance of the Basque-Spanish PWA does not provide clear support for our hypothesis in Basque and manifests unexpected argument structure complexity patterns in Spanish as well. The outcomes of both PWA are further addressed in Section 3.2.. Subsequently, Section 3.3. elaborates on the influence of the experimental settings (i.e., task, domain, and presentation modality) on the argument structure complexity effects observed across our experiments. Finally, Section 3.4. addresses relevant concerns related to bilingualism.

3.1. Argument structure complexity effects in neurotypical speakers

3.1.1. Unaccusativity and transitivity effects in Spanish

Our results from Experiments 1 and 2 support previous evidence suggesting that argument structure complexity effects are not restricted to PWA but extend to neurotypical speakers (e.g., Barbieri et al., 2019; McAllister et al., 2009; Meltzer-Asscher et al., 2015; Momma et al., 2018), reflecting more general patterns of language processing. Specifically, the higher processing costs for Spanish unaccusatives observed across production tasks in Experiments 1 and 2 cannot be attributed to lexical or syntactic impairments in speech processing as they arise even in the absence of such impairments.

The higher SOTs elicited by unaccusatives when compared to unergatives in the sentence production task of Experiment 1 align with previous findings (e.g., Momma et al., 2018), implying that unaccusatives may require advance planning due to the object-like properties of their subject (Section 2.1.3.3.). Hence, these outcomes support the linguistic theories proposing that the sole argument of unergative verbs is the subject, while the argument of unaccusative verbs is actually a direct object occupying the subject position (e.g., Burzio, 1986; Perlmutter, 1978).

The unaccusativity effects observed in Experiment 2 when naming isolated verbs in Spanish go in line with other studies conducted in English (e.g., McAllister et al., 2009; Meltzer-Asscher et al., 2015). Together, these results support the lexicalist view on argument structure (Section 1.2.), i.e., lexical entries contain information specifying their argument structure configuration, including unaccusativity. These observations also imply that verb-related argument structure information becomes available immediately upon lemma selection, supporting the consensus production model (Bock, 1995; Bock & Levelt, 1994; Ferreira & Slevc, 2007; see Section 1.3.1.). Unaccusativity effects in picture naming would not be expected if the argument structure was processed only at later stages of phrase and sentence structure building.

What remains unclear is why the lexical entries of unaccusatives would be more costly to process than those of unergatives, even at the lexical level. Generally, unaccusative effects have been attributed to the non-canonical argument mapping that unaccusatives require, i.e., the mapping of theme/patient role onto a syntactic position usually occupied by an agent (Thompson & Meltzer-Asscher, 2014, p. 152). Consequently, higher processing costs associated with the retrieval of thematic roles that non-canonically map onto functional roles could arise from various distinct sources. These include a greater working memory load needed to compute non-canonical argument mapping when retrieving unaccusative verbs, revision and reevaluation processes related to non-canonical mapping operations, and/or the conceptual accessibility of unaccusative events (i.e., the ease with which the event's mental representation is activated or retrieved from memory (Bock & Warren, 1985, p. 50)). It could for example be computationally more demanding to retrieve the argument structure for an event represented by unaccusative verbs, given that these verbs entail a more complex mapping procedure (Luzzatti & Chierchia, 2002, p. 65). Future studies could aim to distinguish between these and other possible explanations.

A lack of transitivity effects in Spanish at the lexical level implies a hierarchy of factors that influence the processing costs of isolated verbs. Within this hierarchy the number of arguments seems to be ranking lower than the canonicity of their mapping. Our data from Spanish neurotypical speakers are in line with previous studies in English (Meltzer-Asscher et al., 2015) and Italian (Luzzatti et al., 2002), implying that the number of arguments may be less relevant than argument mapping when naming isolated verbs.

We did observe a transitivity effect in Spanish at the sentence level, although not consistently. While no transitivity effects were found in Experiment 1, we found higher error rates elicited by transitives compared to unergatives in Experiment 2, implying that the number of arguments is indeed a relevant factor contributing to higher processing cost at the sentence level. The inconsistency of this effect among Experiments 1 and 2 could be attributed to the differences between tasks in the two experiments (Section 2.2.3.1.), to the ceiling performance on the task in Experiment 1, and/or to the slight differences in scoring procedures among the two tasks. The higher sensitivity of the task in Experiment 2 to the transitivity effects could be viewed as a strength that the task in Experiment 1 does not have. Finally, the argument complexity effects may be sensitive to the modality of stimuli presentation (see Section 3.3. for further discussion on presentation modality). While the sentence production task in Experiment 1 presented stimuli purely in a written form, the sentence elicitation task in Experiment 2 involved only images with no written labels. An image-based elicitation task that requires a verb recall may be better suited to measure argument structure complexity effects than a task that provides written verbs and requires only the recall of its argument(s).

3.1.2. Unergativity effects in Basque

The present thesis tested the hypothesis that ergative case morphology would add an additional layer to argument complexity and increase the processing cost of those verbs in

Basque that assign the ergative case (i.e., unergatives and transitives) compared to those that do not (i.e., unaccusatives).

At the lexical level, the null results in Basque do not provide support for our initial hypothesis. Nevertheless, different patterns in Basque as compared to the effects found in Spanish arise at the sentence level. In the Basque sentence production task of Experiment 1, unergatives elicited more errors compared to transitives and unaccusatives, respectively. In the Basque sentence elicitation task of Experiment 2, unergatives elicited longer SOTs than transitives. Unergative sentences also gave rise to numerically higher error rates than transitive and unaccusative ones. The unergativity effects and trends observed uniquely in Basque imply that argument structure complexity effects can vary across languages. They also partially align with our predictions that ergative case marking increases a verb's processing cost in neurotypical speakers, at least for unergative verbs in the sentence context. However, why did we find effects for unergative but not for transitive verbs, which also assign the ergative case? In Section 2.1.3.2. we suggested that unergatives are more error-prone than transitives in Basque due to the mismatch of their intransitive semantic reading combined with ergative case requirements typical of transitive verbs. This would explain the lack of a parallel ergative case effect for transitives.

The question then arises as to why these unergativity effects arise only in the sentence context? In Basque, the ergative case assignment is overtly expressed only at the sentence level. Perhaps, the mismatch between case assignment and the intransitive nature of unergative verbs generates conflict only at the positional stage of speech production, where sentence building operations need to be computed (Figure 2 in Section 1.3.1.). Under such a scenario, the increase in processing cost would not be expected during action naming, when basic argument structure information is being accessed, but only at the later stages of sentence building, where a conflict arises due to the ergative morphology mismatching the intransitive reading. However, this suggestion is only speculative at the moment and requires further testing.

In answer to research question 1) *Does ergative case marking increase processing costs for Basque verbs that mark their subject with the ergative case (i.e., unergatives and transitives) as compared to those verbs that assign the absolutive case (i.e., unaccusatives) and thus lack an overt case inflection?*, the bigger picture that emerges from our findings in neurotypical speakers suggests that the ergative case affects verbs' processing costs, at least in the context of sentence production, and that the impact of the ergative case varies with verb type. Based on our results, we propose that the factors studied in the present thesis (i.e., ergative case assignment, the number of arguments, and the canonicity of argument mapping) rank in their ability to impact the processing cost of verbs in Basque sentence production as follows: ergative case assignment, when combined with unergatives, is a stronger predictor of increased processing cost than ergative case assignment combined with transitives. The contribution of the canonicity of argument mapping is not consistent across tasks and dependent variables in Basque, but it seems to influence the processing cost to a lesser extent than the ergative case assignment of unergative verbs (Table 14).

In answer to the first part of research question 2) *How do argument structure complexity effects in Basque differ from those in Spanish* ***in neurotypical speakers?***, the unaccusativity and transitivity effects found across Experiments 1 and 2 in Spanish contrast with a lack of parallel effects in Basque. Similarly, unergativity effects found in Basque do not occur in Spanish. We argue that these divergent patterns across the two languages can be explained by the ergative case imposing additional demands on argument structure processing in Basque. The burden of a higher number of arguments or their non-canonical mapping, apparent in Spanish, is not as pronounced in Basque, as these factors are being overridden by (or interact with) ergative case assignment, the impact of which varies with task context and the dependent variable being measured. As a consequence, the argument structure processing effects in Basque do not align with those in Spanish.

Table 14. Observed argument complexity effects and ranking of factors that influence processing costs at the sentence level in Basque production; asterisks mark statistical significance between the highlighted verb type and unergatives.

task (Experiment)	observed hierarchy	factor ranking
sentence production (1)		
error rates	**UNERG**	ergative case + intransitive verb
		>
	> **TRANS*** > **UNACC***	ergative case + transitive verb; non-canonical argument mapping
SOTs	no effect	
sentence elicitation (2)		
error rates	no effect	
SOTs	**UNERG**	ergative case + intransitive verb
		>
	> UNACC > **TRANS***	non-canonical argument mapping; ergative case + transitive verb

3.1.3. A lack of effects in the comprehension domain

We did not observe any argument structure complexity effects across the administered tasks targeting comprehension. Unfortunately, the null effects restrict us from gaining insight into argument structure processes during comprehension. We are also unable to offer novel insights or contribute to the current comprehension models reviewed in Section 1.3.2.. Since these models are not very specific with respect to the integration of argument structure information during comprehension, a considerable gap remains in this area of psycholinguistics.

An alternative way to measure argument structure complexity effects during comprehension could be via a grammaticality judgment type of task that incorporates arguments structure violations. Combined with eye-tracking, this type of task could be better suited to study the relatively small effects of argument structure complexity manipulations within the comprehension domain. Finally, both EEG (e.g., Kielar et al., 2011) and fMRI (e.g., Ben-Shachar et al., 2003; Malyutina & den Ouden, 2017; Meltzer-Asscher et al., 2015; den Ouden et al., 2009; Shetreet et al., 2010; Shetreet & Friedmann, 2012) have proven to be sensitive to neural correlates of distinct argument structure complexity manipulations in comprehension.

3.2. Argument structure complexity effects: PWA

3.2.1. The unaccusativity effects in PWA1

One consistent finding in both PWA and neurotypical speakers of Spanish and English across all three experiments is that unaccusatives appear to cause significantly more difficulties than unergatives. Previous studies (e.g., English: McAlister et al., 2009; Thompson, 2003; Italian: Luzzatti et al., 2002; see also Luzzatti & Chierchia, 2002) report similar results in both unimpaired controls and various subtypes of PWA. On the one hand, these findings imply that unaccusativity effects do not reflect a deficit specific to PWA or to one subtype of aphasia, but rather a general computational cost increase associated with unaccusatives, which affects both PWA and neurotypical speakers. On the other hand, the greater difficulties with unaccusatives for PWA as compared to controls found in previous studies (e.g., Lee & Thompson, 2004; Luzzatti et al., 2002; McAlister et al., 2009) imply additional challenges that PWA have to face when processing unaccusatives. These difficulties could be attributed either to the selective loss of argument structure representation or to disrupted argument structure processing operations.

As argued by Bastiaanse and van Zonneveld (2004), a selective loss of argument structure representation would predict parallel impairments for problematic argument structure configurations (e.g., unaccusatives) in both production and comprehension (note that the theory of lexical access proposed by Levelt et al., 1999 assumes that lemmas are shared across these domains). However, a relatively good performance of PWA1 in the lexical- and sentence-level comprehension tasks in Experiment 3, supported by previous evidence (e.g., Lee & Thompson, 2004; McAlister et al., 2009), implies preserved access to argument structure representations. The more severely disrupted production of unaccusative verbs raises the question of what part of the speech-production system is impoverished in PWA.

Going back to the consensus model of speech production (Bock, 1995; Bock & Levelt, 1994; Ferreira & Slevc, 2007; see Section 1.3.1.), selective impairments could be explained via damage to various argument structure processing operations at different stages of argument structure encoding. These include impairments at the lemma access stage or alternatively, at the post-lemma stage that subserves the lexeme retrieval, phrase structure building, and other syntactic operations (Figure 2 in Section 1.3.1.).

Thompson and colleagues (Kim & Thompson, 2000; Thompson, 2003) proposed the locus of the breakdown to be in accessing the verb's lemma for production. The authors further hypothesized that PWA experience more difficulties when accessing verbs with lexical entries that encode more complex argument structures, including unaccusatives. In contrast, evidence from later studies in the sentence production of unaccusatives in PWA (e.g., Lee & Thompson, 2004; Bastiaanse & van Zonneveld, 2004; 2005) implies that the access to argument structure information is intact but the processes subsequent to lemma access, i.e., the positional level computations such as movement operations or phrase structure building, are impaired. Our data are not entirely consistent with any of these explanations. In Experiment 3, PWA1 failed to retrieve some unaccusative items in action naming while producing the very same items during sentence elicitation. This finding is inconsistent with the view that the breakdown in PWA is due to an inability to access a verb's lemma. If this were the case, the verb and sentence production would be parallelly affected for the same items across both levels of linguistic representations. This behavior is also inconsistent with the view that the post-lemma stage is affected, as this would predict unsuccessful verb retrieval and integration at the sentence level.

The difficulties with unaccusatives in PWA observed in our data could perhaps be accounted for by possible impairments in general cognitive control mechanisms. For example, if canonical argument mapping needs to be suppressed to give rise to the non-canonical mapping associated with unaccusatives, impairments in suppression mechanisms may lead to a poorer performance on unaccusatives in PWA. Considering that neurotypical speakers in Experiments 1 and 2 showed unaccusativity effects parallel to those of PWA1 in Experiment 3, our data from all three experiments could be explained by the additional computational load caused by the non-canonical thematic mapping that unaccusatives require. Unfortunately, we did not test the general cognitive functions of our participants which could provide additional information regarding the exact source of the unaccusativity effects across tested populations and which should certainly be considered when planning future studies.

It is, however, still an open question as to why the action naming of specific unaccusative verbs would be more affected compared to their elicitation in a sentence context. One explanation could be provided by compensatory strategies employed at the sentence level, e.g., the use of contextual information that facilitates lexeme retrieval

(Section 2.3.4.4.1.). Caramazza (1997) suggested that in the presence of brain damage, the lexeme representation and phonological features of a word may be accessed independently of the speaker's prior access to its lemma and syntactic features (contrary to the serial architecture of the consensus model described in Section 1.3.1.). If this were the case, the lexeme and its phonological features could perhaps be activated with the help of sentence context, without the need to process the argument structure information. Nevertheless, more patients with similar dissociations across different experimental contexts would need to be evaluated to test this tentative hypothesis.

3.2.2. The non-converging results in PWA2

Interestingly, the performance of PWA2 in both languages goes against our predictions and her processing cost patterns do not align with the rest of our observations across Experiments 1, 2 and 3. In Spanish, PWA2 does not show the unaccusativity effects observed across all our experiments. On the contrary, her overall performance on unaccusatives in Spanish is actually better when compared to unergatives and transitives. In Basque, her performance does not align with the neurotypical speakers that underperformed on unergatives in Experiments 1 and 2. In addition, her performance in Basque, where she scored overall better on unergatives followed by unaccusatives and transitives, also differs from her outcomes in Spanish.

These puzzling results could be attributed to her etiology (TBI rather than CVA; see Section 2.3.4.5.) and/or to her at-ceiling performance in Spanish and a relatively good performance in Basque. These unfavorable factors make it difficult to integrate her results into the bigger picture arising from Experiments 1, 2 and 3. Unfortunately, during the duration of this PhD project, we did not get an opportunity to test more Basque-Spanish

PWA to shed more light on the contribution of ergative case assignment to argument structure complexity effects in Basque-speaking PWA. Therefore, to properly answer the second part of our research question 2) *How do the argument structure complexity effects in Basque differ from those in Spanish and English in* ***speakers with aphasia?***, more Basque-speaking PWA need to be comprehensively tested. Clearly, this is a limitation that future studies should overcome.

3.3. Domain, task, and modality dependencies of argument structure complexity effects

Our results across all three experiments support previous evidence implying that distinct levels of verb processing seem to require different degrees of access to argument structure information, possibly for the purposes of more efficient word and sentence processing. These levels of processing seem to be determined by the language domain (e.g., Kim & Thompson, 2000; Caramazza, 1997; see also Bock, 1995; Gambi & Pickering, 2017), the task/level of linguistic representation (e.g., Malyutina & den Ouden, 2017; Malyutina & Zelenkova, 2020), and/or the modality of presentation (e.g., den Ouden et al., 2009; see also Gomes et al., 1997; Hillis & Caramazza, 1995).

With respect to different language domains, our observations across production and comprehension (i.e., null results in all comprehension tasks contrasted with various effects found in production tasks) indicate that in comprehension, argument structure information may not need to be actively processed to the same extent as in production. As Garrett (1980) emphasized: “The production system must get the details of form 'right' in every instance, whether those details are germane to sentence meaning or not” (p. 216), which is not necessarily true for the comprehension system. Bock (1995) elaborates on this point, highlighting that the distinct starting points and goals of production and comprehension systems inevitably lead to differences in the level of syntactic detail required to produce versus interpret sentences (p. 205). This does not, of course, imply that argument structure information is not utilized in comprehension or that comprehension is not affected by argument complexity. Although the behavioral measures in comprehension tasks may not lead to significant argument structure complexity effects, argument complexity manipulations can still have measurable impacts at the neurophysiological level (e.g., Malyutina & den Ouden, 2017; Meltzer-Asscher et al., 2015).

Within the production domain, the results from Experiments 1, 2, and 3 imply that the presence of argument structure complexity effects varies with the level of linguistic representation being measured. During single-word production, when lexical access and argument information retrieval are carried out, the canonicity of argument mapping seems to play a more important role than the number of arguments or an ergative case assignment. During sentence production, lemmas with their argument information need to be accessed and retrieved but also actively manipulated for the purposes of sentence-structure building. Here, the number of arguments in Spanish or ergative inflections on unergative subjects in Basque, can override the burden carried by the non-canonical argument mapping associated with unaccusative sentences.

Finally, written, visual, and auditory presentation modalities may differentially affect lexical activation and lead to different time-courses for argument structure processing. Some of the discrepancies in SOTs across Experiment 1 and 2 that we observed might have been affected by the presentation modality. While in Experiment 1 we presented our stimuli in a written form, in Experiment 2 we used visual and auditory modalities. Hence, the comparison across experiments that use different presentation modalities may not be straightforward and should always be considered when comparing and interpreting the results obtained under different presentation conditions (see Section 2.2.3.1. for further discussion).

To sum up, argument structure complexity effects are likely modulated by domain, task and presentation modality contexts. It is advisable to keep this in mind when attempting to compare these effects across distinct experimental conditions. In addition, we endorse more systematic investigation of argument structure complexity effects under various experimental contexts, as also emphasized in previous studies (Malyutina & den Ouden; 2017; Meltzer-Asscher et al., 2015).

3.4. Remarks on bilingualism

In our experimental design, bilingual participants were tested with the incentive to study cross-linguistic differences across a pair of languages with different case alignment systems. Hence, when interpreting our results, we implicitly generalized our findings from bilingual to monolingual speakers. It should be kept in mind that testing bilingual speakers of a selected language pair is not the same as testing two groups of monolinguals. Distinct confounding factors present in bilinguals (e.g., the age of acquisition, the frequency of exposure, or proficiency across modalities) make studying speech processing in bilinguals challenging. When speech impairments co-occur with bilingualism, disentangling these factors from the manifestations of the language impairment turns out to be even more problematic (Grosjean, 1998).

To partially overcome the methodological challenges of our design, the experiments in the present thesis attempted to carefully control for relevant confounding variables including age of acquisition, proficiency across various domains, and frequency of exposure. By doing so, the generalizations are made from as homogeneous a sample of bilinguals as possible. As explained in Section 1.5.5., recruiting a group of Basque monolinguals is virtually impossible, ruling out the option of a between-subject design. However, we believe that the strengths of a within-subject design that provides evidence from distinct languages while controlling for between-subject variability, outweighs its disadvantages.

Conclusion

This thesis provides novel empirical evidence that the ergative case can, under certain conditions, significantly affect the processing cost of verbs. We interpret our major finding that Basque unergatives elicit higher processing costs than other studied verb types in terms of "the apparent mismatch" between their intransitive semantics and transitive morpho-syntactic properties in Basque. This finding is especially compelling since in our experimental designs the same speakers are tested in languages with different case alignment systems. Hence, differential processing patterns across languages cannot be attributed to inter-subject variability, nor can they be reduced to factors of language proficiency and exposure, as demonstrated by additional exploratory analyses. Overall, our results imply that languages with an ergative-absolutive case alignment system, like Basque, do not pattern alike with more commonly studied nominative-accusative languages in terms of argument structure complexity effects, which calls for further cross-linguistic investigation.

With respect to Spanish, higher processing costs associated with the production of unaccusative verbs was found across all three experiments and at various levels of linguistic representation. The unaccusativity effects at the lexical level support the lexicalist view that argument structure configurations, including their mapping patterns, are encoded in verbs' lexical entries. Additionally, the effects found in action naming go in line with the consensus model of speech production, which states that argument structure information is accessed at the lemma activation stage. The longer SOTs for unaccusatives compared to unergatives, which were observed when producing sentences in Spanish, imply that unaccusatives require advance planning, possibly due to the object-like properties of their subjects.

With regards to PWA, the results from PWA1 in both Spanish and English show argument structure complexity patterns predicted by the ASCH and qualitatively similar to those in neurotypical speakers. As expected, these patterns are more prominent in PWA than in unimpaired speakers, implying that speech impairments in PWA do not cause but instead intensify the unaccusativity effects. While the results of PWA1 align with the ASCH and corroborate previous cross-linguistic findings, the performance of PWA2 goes against our predictions for Basque. In addition, her performance in Spanish does not support the predictions of ASCH either. These inconsistent findings are interpreted as arising from the participant's etiology or, alternatively, as being skewed by her relatively high performance. More evidence from Basque speaking PWA, ideally across various aphasia subtypes, is needed to establish if and how ergative case assignment affects verb processing in aphasia.

This research project is the very first attempt to systematically explore argument structure complexity effects in Basque, a language with an ergative-absolutive case alignment system. It is also the first attempt to explore the effect of ergative case assignment on argument structure processing in both neurotypical speakers and Basque-speaking PWA. Recruiting bilingual speakers of languages with different case alignment systems (Basque vs. Spanish and English) enabled us to assess cross-linguistic differences in argument structure processing patterns while controlling for inter-subject variability. The within-subject design used in all experiments capitalizes on fully proficient, simultaneous bilinguals of languages with different morpho-syntactic alignment systems. Such a design, despite its limitations, reduces the overall risk of individual differences impacting cross-linguistic findings. Carefully matched stimuli that repeat across tasks within all three experiments allowed us to comprehensively assess performance at various levels of linguistic representation in both production and comprehension. Such a systematic investigation of argument structure complexity effects is essential, given the domain, task, and presentation dependency of the argument structure complexity effects.

Since the three experiments presented in this work are essentially the first attempt to evaluate the effects of ergative case marking on argument structure processing in both neurotypical speakers and PWA, more evidence is needed to corroborate the reported cross-linguistic differences in processing patterns. Firstly, future empirical research needs to further specify how precisely the ergative case interacts with the number of arguments and canonicity of their mapping and how this interaction affects distinct domains and levels of linguistic representations. Secondly, more time-course sensitive methods should be employed to tease apart various factors involved in the planning processes required for ergative case marking and its interplay with the processing demands associated with other levels of argument structure complexity. Additionally, PWA of various subtypes need to be comprehensively assessed to firmly establish the effects of ergative case marking on performance across verb types with varying argument complexity. Finally, the cross-linguistic evidence derived from future research programs studying the role of case assignment and/or the role of the ergative case in argument structure processing should be accordingly integrated into current models of speech production and comprehension.

To conclude, we would like to highlight the value and importance of studying languages with nominative-accusative alignment in contrast to languages with ergative-absolutive case alignment systems. The unique morpho-syntactic properties of ergative-absolutive languages can provide a window into various cross-linguistic factors involved in argument structure processing. Such cross-linguistic investigations are needed to disentangle universal processing mechanisms from the language-specific ones in an attempt to adequately describe and model distinct speech processes. To properly understand the mechanisms of language processing at an adequate level of abstraction, diverse languages should undergo systematic investigation. Especially in aphasiology, the need to test languages other than English and its Western European relatives is highly pressing (Beveridge & Bak, 2011). Basque is certainly one of the valuable, understudied, and incredibly rich sources for such an endeavor.

References

Ahrens, K. (2003). Verbal integration: The interaction of participant roles and sentential argument structure. *Journal of Psycholinguistics Research*, *32*, 497–516. https:// doi.org/10.1023/A:1025452814385

Ahrens, K., & Swinney, D. (1995). Participant roles and the processing of verbs during sentence comprehension. *Journal of Psycholinguistic Research*, *24*, 533–547. https://doi.org/10.1007/BF02143166

Anderson, R. C., Reynolds, R. E., Schallert, D. L., & Goetz, E. T. (1977). Frameworks for Comprehending Discourse. *American Educational Research Journal, 14*(4), 367–381. https://doi.org/10.3102/00028312014004367

Arantzeta, M., Howard, D., Webster, J., Laka, I., Martínez-Zabaleta, M., & Bastiaanse, R., (2019). Bilingual aphasia: assessing cross-linguistic asymmetries and bilingual advantage in sentence comprehension deficits. *Cortex*, *119*, 195–214. https://doi.org/10.1016/j.cortex.2019.04.003

Agresti, A. (2013). *Categorical data analysis* (3rd ed.). John Wiley.

Barbieri, E., Basso, A., Frustaci M., & Luzzatti, C. (2010). Argument structure deficits in aphasia: new perspective on models of lexical production. *Aphasiology*, *24*(11), 1400–1423. http://dx.doi.org/10.1080/02687030903580325

Barbieri, E., Brambilla, I., Thompson, C. K., & Luzzatti, C. (2019). Verb and sentence processing patterns in healthy Italian participants: Insight from the Northwestern Assessment of Verbs and Sentences (NAVS). *Journal of Communication Disorders*, *79*, 58–75. https://doi.org/10.1016/j.jcomdis.2019.03.001

Bastiaanse, R., & Jonkers, R. (1998). Verb retrieval in action naming and spontaneous speech in agrammatic and anomic aphasia. *Aphasiology*, *12*(11), 951–969. https://doi.org/10.1080/02687039808249463

Bastiaanse R., Edwards S., & Rispens J. (2002). *Verb and Sentence Test.* Thames Valley Test Company.

Bastiaanse, R., & van Zonneveld, R. (2004). Broca's aphasia, verbs and the mental lexicon. *Brain and Language*, *90*, 198–202. https://doi.org/10.1016/S0093-934X(03)00432-2

Bastiaanse, R., & van Zonneveld, R. M. (2005). Sentence production with verbs of alternating transitivity in agrammatic Broca's aphasia. *Journal of Neurolinguistics, 18*, 59–66. https://doi.org/10.1016/j.jneuroling.2004.11.006

Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language, 68,* 255–278. http://doi.org/10.1016/j.jml.2012.11.001

Bates, E., Devescovi, A., & Wulfeck, B. (2001) Psycholinguistics: A cross-language perspective. *Annual Review of Psychology*, *52*, 369–296. https://doi.org/10.1146/annurev.psych.52.1.369

Bates, D., Maechler, M., & Bolker, B. (2012). lme4: Linear mixed-effects models using S4 classes. R version 1.1-23. http://cran.rproject.org/web/packages/lme4/index.html

Baayen, R. H., & Milin, P. (2010). Analyzing reaction times. *International Journal of Psychological Research*, *3*(2), 12–28. https://doi.org/10.21500/20112084.807

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language, 59*, 390–412. https://doi.org/10.1016/j.jml.2007.12.005

Belletti, A., & Contemori, C. (2010). Intervention and attraction. On the production of subject and object relatives by Italian (young) children and adults. In, J. Costa, A. Castro, M. Lobo & F. Pratas (Eds.)*, Language Acquisition and Development, 3: Proceedings of GALA 2009* (pp. 39–52). Cambridge Scholars Publishing.

Belletti, A., & Rizzi, L. (1988). Psych-Verbs and θ-Theory. *Natural Language & Linguistic Theory*, *6*(3), 291–352. https://doi.org/10.1007/BF00133902

Ben-Shachar, M., Hendler, T., Kahn, I., Ben-Bashat, D., & Grodzinsky, Y. (2003). The neural reality of syntactic transformations: evidence from functional magnetic resonance imaging. *Psychological science*, *14*(5), 433–440. https://doi.org/10.1111/1467-9280.01459

Berndt, R. S., Mitchum, C. C., Haendiges, A. N., & Sandson, J. (1997a). Verb retrieval in aphasia: II. Relationship to sentence processing. *Brain and Language*, *56*(1), 107–137. https://doi.org/10.1006/brln.1997.1728

Berndt, R. S., Mitchum, C. C., & Wayland, S. (1997b). Patterns of Sentence Comprehension in Aphasia: A Consideration of Three Hypotheses. *Brain and Language, 60*(2), 197–221. https://doi.org/10.1006/brln.1997.1799

Bever, T. (1970). The cognitive basis for linguistic structures. In J. R. Hayes (Ed.), *Cognition and language development* (pp. 279–362). Wiley & Sons.

Bever, T., & Sanz, M. (1997). Empty categories access their antecedents during comprehension: Unaccusatives in Spanish. *Linguistic Inquiry*, *28*(1), 69–91. https://www.jstor.org/ stable/4178965

Beveridge E. L. M., & Bak T. H. (2011) The languages of aphasia research: Bias and diversity. *Aphasiology*, *25*(12), 1451–1468. https://doi.org/10.1080/02687038.2011.624165

Bialystok E., Craik F. I. M., & Luk G. (2008). Cognitive control and lexical access in younger and older bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 34*, 859–873. https://doi.org/10.1037/0278-7393.34.4.859

de Bleser, R, & Kauschke, C. (2003). Acquisition and loss of nouns and verbs: parallel or divergent patterns? *Journal of Neurolinguistics, 16*(2–3), 213–229. https://doi.org/10.1016/S0911-6044(02)00015-5

Blumstein, S. E., Goodglass, H., Statlender, S., & Biber, C. (1983). Comprehension strategies determining reference in aphasia: a study of reflexivization. *Brain and language*, *18*(1), 115–127. https://doi.org/10.1016/0093-934x(83)90010-x

Bock, K. (1995). Sentence production: From mind to mouth. In J. L. Miller & P. D. Eimas (Eds.), *Speech, language, and communication* (pp. 181–216). Academic Press. https://doi.org/10.1016/B978-012497770-9/50008-X

Bock, K., & Levelt, W. J. (1994). Language production: Grammatical encoding. In M. A. Gernsbacher (Ed.), *Handbook of Psycholinguistics* (pp. 945–984). Academic Press.

Bock, J. K., & Warren, R. K. (1985). Conceptual accessibility and syntactic structure in sentence formulation. *Cognition*, *21*(1), 47–67. https://doi.org/10.1016/0010-0277(85)90023-X

Borer, H. (2003). The Grammar machine. In A. Alexiadou, E. E. Anagnostopoulou & M. Everaert (Eds.), *The Unaccusative Puzzle* (pp. 288–311). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199257652.003.0012

Borer, H. (2005). *Structuring Sense Volume II: The Normal Course of Events*. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199263929.001.0001

Bornkessel I., & Schlesewsky M. (2006). The extended argument dependency model: A neurocognitive approach to sentence comprehension across languages. *Psychological Review*, *113*, 787–821. https://doi.org/10.1037/0033-295X.113.4.787

Bornkessel-Schlesewsky, I., & Schlesewsky, M. (2008). An alternative perspective on "semantic P600" effects in language comprehension. *Brain research reviews*, *59*(1), 55–73. https://doi.org/10.1016/j.brainresrev.2008.05.003

Bornkessel-Schlesewsky, I., & Schlesewsky, M. (2009). The role of prominence information in the real-time comprehension of transitive constructions: A cross-linguistic approach. *Language and Linguistics Compass, 3*(1), 19–58. https://doi.org/10.1111/j.1749-818X.2008.00099.x

Bornkessel-Schlesewsky, I., & Schlesewsky, M. (2013). Reconciling time, space and function: A new dorsal-ventral stream model of sentence comprehension. *Brain and Language, 125*(1), 60–76. https://doi.org/10.1016/j.bandl.2013.01.010

Bowerman, M. (1990). Mapping thematic roles onto syntactic functions: are children helped by innate linking rules? *Linguistics*, *28*, 1253–1289. https://doi.org/10.1515/ling.1990.28.6.1253

Breen, K., & Warrington, E. K. (1994). A study of anomia: evidence for a distinction between nominal and propositional language. *Cortex*, *30*(2), 231–245. https://doi.org/10.1016/s0010-9452(13)80195-5

Brookshire, R. H., & Nicholas, L. E. (1993). *The discourse comprehension test*. Tucson, AZ: Communication Skill Builders/The Psychological Corporation.

de Bruin, A., Carreiras, M., & Duñabeitia, J. A. (2017). The BEST dataset of language proficiency. *Frontiers in Psychology 8*, Article 522. https://doi.org/10.3389/fpsyg.2017.00522

Burzio, L., 1986. *Italian Syntax: A Government-binding Approach*. Springer.

Butt, M. (2006). *Theories of case*. Cambridge University Press. https://doi.org/10.1017/CBO9781139164696

Caley, S., Whitworth, A., & Claessen, M. (2017). Can we separate verbs from their argument structure? A group study in aphasia. *International Journal of Language and Communication Disorders*, *52*, 59–70. https://doi:10.1111/1460-6984.12253

Caplan, D., Waters, G., Dede, G., Michaud, J., & Reddy, A. (2007). A study of syntactic processing in aphasia I: behavioral (psycholinguistic) aspects. *Brain and language*, *101*(2), 103–150. https://doi.org/10.1016/j.bandl.2006.06.225

Caramazza, A. (1997). How many levels of processing are there in lexical access? *Cognitive Neuropsychology*, *14*(1), 177–208.https://doi.org/10.1016/0093-934x(76)90048-1

Caramazza, A., & Zurif, E. B. (1976). Dissociation of algorithmic and heuristic processes in language comprehension: evidence from aphasia. *Brain and language*, *3*(4), 572–582. https://doi.org/10.1016/0093-934x(76)90048-1

Carreiras, M., Duñabeitia, J. A., Vergara, M., de la Cruz-Pavía, I., & Laka, I. (2010). Subjectrelative clauses are not universally easier to process: Evidence from Basque. *Cognition*, *115*(1), 79–92. https://doi.org/10.1016/j.cognition.2009.11.012

Chang, F., Dell, S. G., & Bock, K. (2006). Becoming syntactic. *Psychological Review*, *113*(2), 234–272. https://doi.org/10.1037/0033-295X.113.2.234

Chapman, S. B., Gamino, J. F., Cook, L. G., Hanten, G., Li, X., & Levin, H. S. (2006). Impaired discourse gist and working memory in children after brain injury. *Brain and language*, *97*(2), 178–188. https://doi.org/10.1016/j.bandl.2005.10.002

Cheng, L., & Demirdache, H. (1993). External arguments in Basque. In J.I. Hualde & J. Ortiz de Urbina (Eds.), *Generative studies in Basque linguistics* (pp. 71–287). John Benjamins. https://doi.org/10.1075/cilt.105.03che

Chomsky, N. (1981). *Lectures on government and binding: The Pisa lectures*. Foris.

Contreras, H. (1991). On the position of subjects. In S. Rothstein (Ed.), *Perspectives on Phrase Structure: Heads and Licensing* (pp. 63–79). Academic Press. https://doi.org/10.1163/9789004373198

Cho-Reyes, S., & Thompson, C. K. (2012). Verb and sentence production and comprehension in aphasia: Northwestern Assessment of Verbs and Sentences (NAVS). *Aphasiology*, *26*(10), 1250–1277. https://doi.org/10.1080/02687038.2012.693584

Costa, J., Lobo, M., & Silva, C. (2011). Subject-object asymmetries in the acquisition of Portuguese relative clauses: Adults vs. children. *Lingua, 121*(6), 1083–1100. https://doi.org/10.1016/j.lingua.2011.02.001

Crawford, J. R., Garthwaite, P. H., & Ryan, K. (2011). Comparing a single case to a control sample: testing for neuropsychological deficits and dissociations in the presence of covariates. *Cortex*, *47*(10), 1166–1178. https://doi.org/10.1016/j.cortex.2011.02.017

Crutch, S. J., & Warrington, E. K. (2003). Preservation of Prepositional Speech in a Pure Anomic: The Importance of an Abstract Vocabulary. *Neurocase, 9*(6), 465–481. https://doi.org/10.1076/neur.9.6.465.29373

Cuetos Vega, F., & González Nosti, M. (2009). *BETA: Batería para la Evaluación de los Trastornos Afásicos: manual*. Instituto de Orientación Psicológica EOS.

Cutler, A., & Clifton, C. (1999). Comprehending spoken language: A blueprint of the listener. In C. M. Brown & P. Hagoort (Eds.), *The Neurocognition of Language* (pp. 123–166). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780198507932.003.0005

Dell, G. S., & Sullivan, J. M. (2004). Speech errors and language production: Neuropsychological and connectionist perspectives. In B. H. Ross (Ed.), *The Psychology of Learning and Motivation* (pp. 63–108). Elsevier.

van Dijk, T. A., & Kintsch, W. (1983). *Strategies of Discourse Comprehension*. New York: Academic Press.

Dorie, V. (2015). Bayesian Linear Mixed-Effects Models, version, 1.0-4. https://cran.r-project.org/web/packages/blme/index.html

Dowty, D. (1991). Thematic proto-roles and argument selection. *Language*, *67*, 547–619.

Dragoy, O., & Bastiaanse, R. (2010). Verb production and word order in Russian agrammatic speakers. *Aphasiology*, *24*(1), 28–55. https://doi.org/10.1080/02687030802586902

Druks, J., & Masterson, J. (2000). *An object and action naming battery*. Psychology Press.

Dunn, L. M., & Dunn, L. M. (1981). Peabody Picture Vocabulary Test-Revised. American Guidance Service, Inc.

Edmonds, L. A. (2016). A review of verb network strengthening treatment: Theory, methods, results, and clinical implications. *Topics in Language Disorders, 36*(2), 123–135. https://doi.org/10.1097/TLD.0000000000000088

Edwards, S., & Bastiaanse, R. (1998). Diversity in the lexical and syntactic abilities of fluent aphasic speakers. *Aphasiology*, *12*(2), 99–117. https://doi.org/10.1080/02687039808250466

Egurtzegi, A., Blasi, D. E., Bornkessel-Schlesewsky, I., Laka, I., Meyer, M., Bickel, B., & Sauppe, S. (2022). Cross-linguistic differences in case marking shape neural power dynamics and gaze behavior during sentence planning. *Brain and language*, *230*, 105–127. https://doi.org/10.1016/j.bandl.2022.105127

Elwood, R. W. (1991). The Wechsler Memory Scale-Revised: psychometric characteristics and clinical application. *Neuropsychology review*, *2*(2), 179–201. https://doi.org/10.1007/BF01109053

Embick, D., & R. Noyer. (2007). Distributed Morphology and the syntax-morphology interface. In G. Ramchand & C. Reiss (Eds.), *The Oxford Handbook of Linguistic Interfaces* (pp. 289–324). Oxford University Press.

Ezeizabarrena, M. (2012). The (in)consistent ergative marking in early Basque: L1 vs. child L2. *Lingua, 122*, 303–317. https://doi.org/10.1016/j.lingua.2011.11.009

Fergadiotis, G., & Wright H. H. (2016). Modeling confrontation naming and discourse performance in aphasia. *Aphasiology*, *30*, 364–380. https://doi.org/10.1080/02687038.2015.1067288

Ferreira, V. S. & Slevc, L. R. (2007). Grammatical encoding. In M. G. Gaskell (Ed.), *The Oxford Handbook of Psycholinguistics* (pp. 453–469). Oxford University Press.

Fillmore, C. J. (1968). The case for case. In E. Bach & R. Harms (Eds.), *Universals in Linguistic Theory* (pp. 1–88). Holt, Rinehart and Winston.

Fillmore, C. J. (1971). Types of lexical information. In D. D. Steinberg & L. A. Jakobovits (Eds.), *Semantics: An interdisciplinary reader in philosophy, linguistics and psychology* (pp. 370–392). Cambridge University Press.

Folli, R., & Harley, H. (2008). Teleology and animacy in external arguments. *Lingua*, *118*(2), 190–202. https://doi.org/10.1016/J.LINGUA.2007.02.004

Frazier, L. (1987) Theories of sentence processing. In J. Garfield J. (Ed.), *Modularity in Knowledge Representation and Natural-Language Processing* (pp. 291–307). The MIT Press.

Frazier, L, & Fodor, J. D. (1978). The sausage machine: a new two-stage model of the parser. *Cognition, 6*, 291–325. https://doi.org/10.1016/0010-0277(78)90002-1

Friederici, A. D. (2002). Towards a neural basis of auditory sentence processing. *Trends in Cognitive Sciences*, *6*, 78–84. https://doi.org/10.1016/s1364-6613(00)01839-8

Friederici, A. D. (2011). The brain basis of language processing: from structure to function. *Physiological reviews*, *91*(4), 1357–1392. https://doi.org/10.1152/physrev.00006.2011

Friederici A. D, & Frisch S. (2000). Verb-argument structure processing: the role of verb-specific and argument-specific information. *Journal of Memory and Language*, *43*, 476–507. https://doi.org/10.1006/jmla.2000.2709

Friederici, A., & Levelt, W. J. M. (1988). Sprache. In K. Immelmann, K. Scherer, C. Vogel, & P. Schmook (Eds.), *Psychobiologie: Grundlagen des Verhaltens* (pp. 648–671). Fischer.

Friedmann, N. (2008). Traceless relatives: Agrammatic comprehension of relative clauses with resumptive pronouns. *Journal of Neurolinguistics, 21*, 138–149. https://doi.org/10.1016/j.jneuroling.2006.10.005

Friedmann, N., & Novogrodsky, R. (2004). The acquisition of relative clause comprehension in Hebrew: a study of SLI and normal development. *Journal of child language*, *31*(3), 661–681. https://doi.org/10.1017/s0305000904006269

Gabry, J., Ali, I., Brilleman, S., Novik, J. B., Wood, S., Bates, D. … Goodrich, B. (2020). rstanarm: Bayesian applied regression modeling via Stan, version 2.21.1. https://mc-stan.org/rstanarm/

Gambi, C., & Pickering, M. J. (2017). Models Linking Production and Comprehension. In E. M. Fernández, & H. S. Cairns (Eds.), *The Handbook of Psycholinguistics* (pp. 157–181). John Wiley & Sons.https://doi.org/10.1002/9781118829516.ch7

Garrett, M. F. (1980). Levels of processing in sentence production In Butterworth B (Ed.), *Language production*. *Vol. 1: Speech and talk* (pp. 176–220). Academic Press.

Gollan, T. H., Montoya, R. I., Fennema-Notestine, C., & Morris, S. K. (2005). Bilingualism affects picture naming but not picture classification. *Memory & cognition*, *33*(7), 1220–1234. https://doi.org/10.3758/bf03193224

Gollan, T.H., Weissberger, G.H., Runnqvist, E., Montoya, R.I., & Cera, C.M. (2012). Self-ratings of spoken language dominance: Multi-Lingual Naming Test (MiNT) and Preliminary Norms for Young and Aging Spanish-English Bilinguals. *Bilingualism*, *15*(3), 594–615.

Gomes, H., Ritter, W., Tartter, V. C., Vaughan, H. G., Jr., & Rosen, J. J. (1997). Lexical processing of visually and auditorily presented nouns and verbs: evidence from reaction time and N400 priming data. *Brain research. Cognitive brain research*, *6*(2), 121–134. https://doi.org/10.1016/s0926-6410(97)00023-2

Grimshaw, J. B. (1990). *Argument structure*. MIT press.

Grosjean, F. (1998). Studying bilinguals: methodological and conceptual issues. *Bilingualism: Language and cognition*, *1*, 131–149. https://doi:10.1017/S136672899800025X

Gruber, J. S. (1965). *Studies in lexical relations*. [Doctoral dissertation. Massachusetts Institute of Technology].

Gutierrez-Mangado, M. J. (2011). Children's comprehension of relative clauses in an ergative language: the case of Basque. *Language Acquisition: A Journal of Developmental Linguistics*, *18*, 176–201. https://doi.org/10.1080/10489223.2011.580674

Hadar, U., Jones, C., & Mate-Kole, C. (1987). The disconnection in anomic aphasia between semantic and phonological lexicons. *Cortex*, *23*, 505–517. https://doi.org/10.1016/S0010-9452(87)80011-4

Hafri, A., Trueswell, J. C., & Strickland, B. (2018). Encoding of event roles from visual scenes is rapid, spontaneous, and interacts with higher-level visual processing. *Cognition*, *175*, 36–52. https://doi.org/10.1016/j.cognition.2018.02.011

Hagen, C. (1984). Language disorders in head trauma. In A. Holland (Ed.), *Language Disorders in Adults* (pp. 246–281). College Hill Press.

Hanne, S., Burchert, F., de Bleser, R., & Vasishth, S. (2015). Sentence comprehension and morphological cues in aphasia: What eye-tracking reveals about integration and prediction. *Journal of Neurolinguistics*, *34*, 83–111. https://doi.org/10.1016/j.jneuroling.2014.12.003

Heinzova, P., Carreiras, M., & Mancini, S. (2023). Processing argument structure complexity in Basque-Spanish bilinguals. *Language, Cognition and Neuroscience*, *38*(5), 745–763. https://doi.org/10.1080/23273798.2022.2154370

Helm-Estabrooks, N., & Nicholas, M. (2003). *Narrative Story Cards*. Pro-Ed, Inc.

Hillis, A. E., & Caramazza, A. (1995). Representation of grammatical categories of words in the brain. *Journal of cognitive neuroscience*, *7*(3), 396–407. https://doi.org/10.1162/jocn.1995.7.3.396

Hinchliffe, F. J., Murdoch, E., & Chenery, H. J. (1998). Towards a conceptualization of language and cognitive impairment in closed-head injury: use of clinical measures. *Brain Injury*, *12*(2), 109–132. https://doi.org/10.1080/026990598122746

Holland, A. L. (1982). When is aphasia aphasia? The problem of closed head injury. In R. Brookshire (Ed.), *Clinical Aphasiology Proceedings* (pp. 345–349). BRK Publishers.

Huber, W. (1990). Text comprehension and production in aphasia: Analysis in terms of micro- and macroprocessing. In: Y. Joanette & H. H. Brownell(Eds.), *Discourse Ability and Brain Damage* (pp. 154–179). Springer. https://doi.org/10.1007/978-1-4612-3262-9_7

Ivanova. I., & Costa A. (2008). Does bilingualism hamper lexical access in speech production? *Acta Psychologica*, *127*, 277–288. https://doi: 10.1016/j.actpsy.2007.06.003.

Jackendoff, R. (1972). *Semantic Interpretation in Generative Grammar*. The MIT Press.

Jackendoff, R. (1983). *Semantics and Cognition*. The MIT Press.

Jackendoff, R. (1990). *Semantic structures*. The MIT Press.

Jackendoff, R. (2015). Genesis of a theory of language: From thematic roles (source) to the Parallel Architecture (goal). [Unpublished manuscript]. https://doi.org/ 10.13140/RG.2.1.1500.3602.

Jeffreys, H. (1961). *The Theory of Probability* (3rd ed.). Oxford University Press.

Kavé, G., & Goral, M. (2017). Do age-related word retrieval difficulties appear (or disappear) in connected speech? *Neuropsychology, development, and cognition. Section B, Aging, neuropsychology and cognition*, *24*(5), 508–527. https://doi.org/10.1080/13825585.2016.1226249

Kauschke, C., & von Frankenberg, J. (2008). The differential influence of lexical parameters on naming latencies in German: *A study on noun and verb picture naming. Journal of Psycholinguistic Research, 37*(3), 243–257. https:// doi.org/10.1007/s10936-007-9068-5

Kauschke, C., & Stenneken, P. (2008). Differences in noun and verb processing in lexical decision cannot be attributed to word form and morphological complexity alone. *Journal of Psycholinguistic Research, 37*(6), 443–452. https://doi.org/ 10.1007/s10936-008-9073-3

Kegl, J. (1995). Levels of representation and units of access relevant to agrammatism. *Brain and Language*, 50, 151–200. https://doi.org/10.1006/brln.1995.1044

Keller, F., & Sorace, A. (2003). Gradient auxiliary selection and impersonal passivization in German: An experimental investigation. *Journal of Linguistics, 39*, 57–108. https://doi.org/ 10.1017/S0022226702001676

Keuleers, E., & Brysbaert, M. (2010). Wuggy: A multilingual pseudoword generator. *Behavior Research Methods*, *42*(3), 627–633. https://doi.org/10.3758/BRM.42.3.627

Kielar, A., Meltzer-Asscher, A., & Thompson, C. (2011). ERP responses to argument structure and semantic violations in sentence context in healthy and agrammatic aphasic adults. *Procedia - Social and Behavioral Sciences*, *23*, 45–46. https://doi.org/10.1016/j.sbspro.2011.09.162

Kim, M., & Thompson, C. K. (2000). Patterns of comprehension and production of nouns and verbs in agrammatism: implications for lexical organization. *Brain and language*, *74*(1), 1–25. https://doi.org/10.1006/brln.2000.2315

Kim, M., & Thompson, C. K. (2004). Verb deficits in Alzheimer's disease and agrammatism: implications for lexical organization. *Brain and language*, *88*(1), 1–20. https://doi.org/10.1016/s0093-934x(03)00147-0

King, K. A., Hough, M. S., Walker, M. M., Rastatter, M., & Holbert, D. (2006). Mild traumatic brain injury: effects on naming in word retrieval and discourse. *Brain injury*, *20*(7), 725–732. https://doi.org/10.1080/02699050600743824

Kintsch, W., & van Dijk, T. A. (1978). Toward a model of text comprehension and production. *Psychological Review, 85*(5), 363–394. https://doi.org/10.1037/0033-295X.85.5.363

Kong, A. P. (2022). *Analysis of Neurogenic Disordered Discourse Production: Theories, Assessment and Treatment* (2nd ed.). Routledge.

Laka, I. (1996). *A brief grammar of Euskera, the Basque Language*. University of the Basque Country (EHU-UPV). http://www. ehu.eus/HEB/itziar_laka/

Laka, I. (2006). On the nature of case in Basque: structural or inherent? In: H. Broekhuis, N. Corver, J. Koster, R. Huybregts, & U. Kleinhenz (Eds.), *Organizing Grammar* (pp. 374–382). Mouton de Gruyter. https://doi.org/10.1515/9783110892994.374

Laka, I., & Erdocia, K. (2012). Linearization preferences given "free word order"; subject preferences given ergativity: A look at Basque. In E. Torrego (Ed.), *Of grammar, words, and verses: In honor of Carlos Piera* (pp. 115–142). Oxford University Press.

Leckart, B. T., & Bakan, P. (1965). Complexity Judgments of Photographs and Looking Time. *Perceptual and Motor Skills, 21*(1), 16–18. https://doi.org/10.2466/pms.1965.21.1.16

Lee, J., & Thompson, C. K. (2011). Real-time production of unergative and unaccusative sentences in normal and agrammatic speakers: An eyetracking study. *Aphasiology*, *25*(6–7), 813–825. https://doi.org/10.1080/02687038.2010.542563

Lee, M., & Thompson, C. K. (2004). Agrammatic aphasic production and comprehension of unaccusative verbs in sentence contexts. *Journal of Neurolinguistics*, *17*(4), 315–330. https://doi.org/10.1016/S0911-6044(03)00062-9

Legendre, G., Miyata, Y., & Smolensky, P. (1991) Unifying Syntactic and Semantic Approaches to Unaccusativity: A Connectionist Approach. *Proceedings of the Seventeenth Annual Meeting of the Berkeley Linguistics Society: General Session and Parasession on The Grammar of Event Structure* (pp. 156–167). https://doi.org/10.3765/bls.v17i0.1643

Legendre, G., & Sorace, A. (2003). Auxiliaries and Intransitivity in French and in Romance. In D. Godard (Ed.), *Les langues romanes: Problemes de la phrase simple* (pp. 185–234). Editions du CNRS.

Lenth, R., Love, J., & Harve, M. (2018). Emmeans: Estimated marginal means, aka least-squares means, version 1.4.8. https://cran.rproject.org/web/packages/emmeans/index.html

Levelt, W. J. (1989). *Speaking: From intention to articulation*. The MIT Press.

Levelt, W. J. (1999a). Language production: a blueprint of the speaker. In C. M. Brown & P. Hagoort (Eds.), *The Neurocognition of Language* (pp. 83–122). Oxford University Press.

Levelt, W. J. (1999b). Models of word production. *Trends in Cognitive Science, 3*(6), 223–232. https://doi.org/10.1016/s1364-6613(99)01319-4

Levelt, W. J. (2001). Spoken word production: a theory of lexical access. *Proceedings of the National Academy of Sciences of the United States of America*, *98*(23), 13464–13471. https://doi.org/10.1073/pnas.231459498

Levelt, W. J., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Science*, *22*, 1–75. https://doi.org/10.1017/S0140525X99001776

Levin, B. (1983). *On the nature of ergativity*. [Doctoral dissertation. Massachusetts Institute of Technology].

Levin, B. (1991) Building a Lexicon: The Contribution of Linguistics. *International Journal of Lexicography*, *4*(3), 205–226. https://doi.org/ 10.1093/IJL/4.3.167

Levin, B., & Rappaport, M. (1986). The formation of adjectival passives. *Linguistic Inquiry, 17*, 623–661.

Levin, B., & Rappaport Hovav, M. (1995). *Unaccustivity: At the syntax-lexical semantics interface*. The MIT Press.

Levin, B., & Rappaport Hovav, M. (2005). *Argument realization*. Cambridge University Press.

Lieber, R., & Baayen, H. (1997). *Natural Language and Linguistic Theory, 15(4),* 789–845. https://doi.org/10.1023/a:1005897301225

Lindsley, J. R. (1975). Producing simple utterances: How far ahead do we plan? *Cognitive Psychology, 7*, 1–19. https://doi.org/10.1016/0010-0285(75)90002-X

Lohndal, T. (2020) Syntactic Categorization of Roots. In *Oxford Research Encyclopedia of Linguistics*. Oxford University Press. https://doi.org/10.1093/acrefore/9780199384655.013.257

Lemhöfer, K., & Broersma, M. (2012). Introducing LexTALE: a quick and valid lexical test for advanced learners of English. *Behavioral Research Methods, 44*(2), 325–343. https://doi.org/10.3758/s13428-011-0146-0

Lomas, J., Pickard, L., Bester, S., Elbard, H., Finlayson, A., & Zoghaib, C. (1989). The communicative effectiveness index: development and psychometric evaluation of a functional communication measure for adult aphasia. *The Journal of speech and hearing disorders*, *54*(1), 113–124. https://doi.org/10.1044/jshd.5401.113

Loverso, F. L., Prescott, T. E., & Selinger, M. (1988). Cueing verbs: a treatment strategy for aphasic adults (CVT). *Journal of rehabilitation research and development*, *25*(2), 47–60.

Luzzatti, C., & Chierchia, G. (2002). On the nature of selective deficits involving nouns and verbs. *The Italian Journal of Linguistics, 14*, 43–71.

Luzzatti, C., Ingignoli, C., Crepaldi, D., & Semenza, C. (2006). Noun-verb dissociation in aphasia: Type/token differences in the analysis of spontaneous speech. *Brain and Language, 99*(1–2), 170–171. https://doi:10.1016/j.bandl.2006.06.094

Luzzatti, C., Raggi, R., Zonca, G., Pistarini, C., Contardi, A., & Pinna, G. D. (2002). Verb-noun double dissociation in aphasic lexical impairments: the role of word frequency and imageability. *Brain and language*, *81*(1–3), 432–444. https://doi.org/10.1006/brln.2001.2536

Makowski, D. (2018). The Psycho Package: An Efficient and Publishing-Oriented Workflow for Psychological Science. *Journal of Open Source Software*, *3*(22), 470. https://doi.org/10.21105/joss.00470

Makowski, D., Ben-Shachar, M. S., & Lüdecke, D. (2019). bayestestR: Describing Effects and their Uncertainty, Existence and Significance within the Bayesian Framework. *Journal of Open Source Software, 4*(40), 1541. http://dx.doi.org/10.21105/joss.01541

Malyutina, S., & den Ouden, D. B. (2015). High-definition tDCS of noun and verb retrieval in naming and lexical decision. *NeuroRegulation, 2*(3), 111–125. https://doi.org/10.15540/ nr.2.3.111

Malyutina, S., & den Ouden, D. B. (2017). Task-dependent neural and behavioral effects of verb argument structure. Brain and Language, 168, 57–72. https://doi.org/10. 1016/j.bandl.2017.01.006

Malyutina, S., Richardson, J. D., & den Ouden, D. B. (2016). Verb Argument Structure in Narrative Speech: Mining AphasiaBank. *Seminars in speech and language*, *37*(1), 34–47. https://doi.org/10.1055/s-0036-1572383

Malyutina, S., & Zelenkova, V. (2020). Verb argument structure effects in aphasia are different at single-word versus sentence level. *Aphasiology*, *34*(4), 431–457. https://doi.org/10.1080/02687038.2019.1697866

Manning, L., & Warrington, E. K. (1996). Two routes to naming: a case study. *Neuropsychologia*, *34*(8), 809–817. https://doi.org/10.1016/0028-3932(95)00166-2

Marantz, A. (1997). No escape from syntax: Don't try morphological analysis in the privacy of your own lexicon. In A. Dimitriadis, L. Siegel, C. Surek-Clark & A. Williams (Eds.), *University of Pennsylvania Working Papers in Linguistics, Vol. 4.2* (pp. 201–225). University of Philadelphia. https://repository.upenn.edu/pwpl/vol4/iss2/14

Marian, V., Blumenfeld, H. K., Kaushanskaya, M. (2007). The Language Experience and Proficiency Questionnaire (LEAP-Q): Assessing Language Profiles in Bilinguals and Multilinguals. *Journal of Speech, Language and Hearing Research*, *50*(4), 940–67. https://doi.org/10.1044/1092-4388(2007/067)

Marslen-Wilson, W., & Tyler, L. K. (1980). The temporal structure of spoken language understanding. *Cognition*, *8*, 1–71. https://doi.org/10.1016/0010-0277(80)90015-3

Martinez de la Hidalga, G., Zawiszewski, A., & Laka, I. (2019). Eppur non si muove: Experimental evidence for the unaccusative hypothesis and distinct ϕ-feature processing in Basque. *Glossa: A Journal of General Linguistics*, *4*(1), 1–19. Article 120. http://hdl.handle.net/10810/41847 https://doi. org/10.5334/gjgl.829

Martínez-Ferreiro, S., Bachrach, A., Sanchez-Alonso, S., & Picallo, C. (2014). Canonicity and thematic roles in agrammatism. In I. Moreno-Torres Sánchez, E. Moruno López & S. Madrid Cánovas (Eds.), *Avances en Lingüística Clínica. Selección de Comunicaciones del III Congreso Internacional de Lingüística Clínica* (pp. 9–22). University of Málaga.

Mayer, J., & Murray, L. (2003) Functional measures of naming in aphasia: Word retrieval in confrontation naming versus connected speech. *Aphasiology*, *17*(5), 481–497. https://doi.org/10.1080/02687030344000148

McAllister, T., Bachrach A., Waters G., Michaud J., & Caplan, D. (2009). Production and comprehension of unaccusatives in aphasia. *Aphasiology*, *23*(7–8), 989–1004. https://doi.org/10.1080/02687030802669518

McClelland, J. L., & Kawamoto, A. H., (1986). Mechanisms of sentence processing: assigning roles to constituents of sentences. In J. McClelland, D. Rumelhart & t. P. R. Group (Eds.), *Parallel Distributed Processing: Explorations in the Microstructure of Cognition*, *Vol. 2* (pp. 272–325). The MIT Press.

Meltzer-Asscher, A., Mack, J. E., Barbieri, E., & Thompson, C. K. (2015). How the brain processes different dimensions of argument structure complexity: Evidence from fMRI. *Brain and Language*, *142*, 65–75. https://doi.org/10.1016/j.bandl.2014.12.005

Miceli, G., Silveri, M. C., Nocentini, U., & Caramazza, A. (1988). Patterns of dissociation in comprehension and production of nouns and verbs. *Aphasiology*, *2*, 351–358. https://doi.org/10.1080/02687038808248937

de Miguel, E. (1992). *El aspecto en la sintaxis del español: Perfectividad e impersonalidad*. Ediciones de la Universidad Autónoma de Madrid.

Momma, S., Slevc, L. R., & Phillips, C. (2016). The timing of verb selection in Japanese sentence production. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *42*(5), 813–824. https://doi.org/10.1037/xlm0000195

Momma, S., Slevc, R., & Phillips, C. (2018). Unaccusativity in sentence production. *Linguistic Inquiry, 49*(1), 181–194. https://doi.org/10.1162/LING_a_00271

Munarriz, A., Ezeizabarrena, M. J., & Gutierrez-Mangado, M. J. (2016). Differential and selective morpho-syntactic impairment in Spanish-Basque bilingual aphasia. *Bilingualism: Language and Cognition*, *19*(4), 810–833. https://doi.org/doi:10.1017/S136672891400042X

Nickels, L., Fischer-Baum, S., & Best, W. (2022). Single case studies are a powerful tool for developing, testing and extending theories. Nature Review Psychology, *1*, 733–747. https://doi.org/10.1038/s44159-022-00127-y den Ouden, D. B., Fix, S., Parrish, T. B., & Thompson, C. K. (2009). Argument structure effects in action verb naming in static and dynamic conditions. *Journal of neurolinguistics*, *22*(2), 196–215. https://doi.org/10.1016/j.jneuroling.2008.10.004

den Ouden, D. B., Malyutina, S., Basilakos, A., Bonilha, L., Gleichgerrcht, E., Yourganov, G., Hillis, A. E., Hickok, G., Rorden, C., & Fridriksson, J. (2019). Cortical and structural-connectivity damage correlated with impaired syntactic processing in aphasia. *Human brain mapping*, *40*(7), 2153–2173. https://doi.org/10.1002/hbm.24514

Paradis, M. (2004). *A Neurolinguistic Theory of Bilingualism*. John Benjamins Publishing.

Pashek, G. V., & Tompkins C. A. (2002). Context and word class influences on lexical retrieval in aphasia. *Aphasiology*, 16, 261–286. https://doi.org/10.1080/02687040143000573

Peirce, J. W. (2007). PsychoPy - Psychophysics software in Python. *Journal of Neuroscience Methods, 162*(1–2), 8–13. https://doi.org/10.1016/j.jneumeth.2006.11.017

Perlmutter, D. (1978). Impersonal passives and the unaccusative hypotheses. Paper presented at *the Fourth Annual Meeting of the Berkeley Linguistics Society*.

Pineda, A., & Berro, A. (2020). Hybrid intransitives in Basque. *Glossa: A Journal of General Linguistics, 5*(1), 1–28. https://doi.org/10.5334/gjgl.824

Pourquié, M. (2013) Verb processing in Basque and French agrammatic aphasia: A "post-lexical access" deficit. *Aphasiology*, *27*(12), 1472–1510. https://doi.org/10.1080/02687038.2013.808735

Pylkkänen, L. (2008). Introducing Arguments. MIT Press. https://doi.org/10.7551/mitpress/9780262162548.001.0001

R Core Team (2012). R: A language and environment for statistical computing. R Foundation for Statistical Computing. R version 3.6.3. https://www.r-project.org/

Ramchand, G. C. (2008). *Verb Meaning and the Lexicon*: *A First-Phase Syntax*. Cambridge University Press.

Ramchand, G. C. (2013). Argument structure and argument structure alternations. In den Dikken, M. (Ed.), *The Cambridge handbook of generative syntax* (pp. 265–321). Cambridge University Press.

Ramchand, G. (2014). Creating a productive space for theory and experimentation. In A. Bachrach, I. Roy & L. Stockall (Eds.), *Structuring the argument: Multidisciplinary research on verb argument structure* (pp. 185–200). John Benjamins.

Rappaport Hovav, M., &Levin, B. (2000). Classifying Single Argument Verbs. In P. Coopmans, M. Everaert & J. Grimshaw (Eds.), *Lexical Specification and Insertion* (pp. 269–304). John Benjamins.

Raven, J. C., Court, J. H., & Raven, J. (1995). *Coloured Progressive Matrices*. Oxford Psychologists Press.

Robinson, G., Blair, J., & Cipolotti, L. (1998). Dynamic aphasia: an inability to select between competing verbal responses? *Brain: a journal of neurology*, *121*(1), 77–89. https://doi.org/10.1093/brain/121.1.77

Rodriguez-Fornells, A., Krämer, U. M., Lorenzo-Seva, U., Festman, J., & Münte, T. F. (2012). Self-assessment of individual differences in language switching. *Frontiers in psychology*, *2*, 388. https://doi.org/10.3389/fpsyg.2011.00388

Rodríguez-Ordóñez, I. (2015). The acquisition of nominal and verbal inflectional morphology: Evidence from Basque ergativity in adult L2 speakers. *BUCLD 39: Supplement to Proceedings of the 39th Annual Boston University Conference on Language Development.*

Roelofs, A. (1992) A spreading-activation theory of lemma retrieval in speaking. *Cognition*, *42*, 107–142. https://doi.org/10.1016/0010-0277(92)90041-F

Rosen, C. (1984). The interface between semantic roles and initial grammatical relations. In D. M. Perlmutter & C. Rosen (Eds.), *Studies in Relational Grammar 2* (pp. 38–77). Chicago University Press.

Rossi, E., & Bastiaanse, R. (2008). Spontaneous speech in Italian agrammatic aphasia: a focus on verb production. *Aphasiology*, *22*(4), 347–362. https://doi.org/10.1080/02687030701407093

Roux, F., Armstrong, B. C., & Carreiras, M. (2016). Chronset: An automated tool for detecting speech onset. *Behavior Research Methods, 49*(5), 1864–1881. https://doi.org/10.3758/s13428-016-0830-1

Rumelhart, D. (1980). Schemata: The Building Blocks of Cognition. In R. J. Spiro, B. C. Bruce & W. E. Brewer (Eds.), *Theoretical Issues in Reading Comprehension* (pp. 33–58), Erlbaum. https://doi.org/10.4324/9781315107493-4

Rumelhart, D. E., Lindsay, P. H., & Norman, D. A. (1972). A process model for long-term memory. In E. Tulving & W. Donaldson (Eds.), *Organization of memory* (pp. 197–246). Academic Press.

Rumelhart, D. E, & Norman, D. A. (1973). Active semantic networks as a model of human memory. *Proc. Third IJCAI, Stanford University* (pp. 450–457). Stanford.

Rumelhart, D. E., & Ortony, A. (1977). The representation of knowledge in memory. In R. C. Anderson, R.J. Spiro & W.E. Montague (Eds.), *Schooling and the acquisition of knowledge* (pp. 99–135). Lawrence Erlbaum.

Rissman, L., & Majid, A. (2019). Thematic roles: Core knowledge or linguistic construct? *Psychonomic Bulletin & Review, 26*(6), 1850–1869. https://doi.org/10.3758/s13423-019-01634-5

Saffran, E. M., Berndt, R. S., & Schwartz, M. F. (1989). The quantitative analysis of agrammatic production: procedure and data. *Brain and language*, *37*(3), 440–479. https://doi.org/10.1016/0093-934x(89)90030-8

Sanchez-Alonso, S., Martínez-Ferreriro, S., & Bastiaanse, R. (2011). Clitics in Spanish Agrammatic Aphasia: A Study of the Production of Unaccusative, Reflexive and Object Clitics. In I. Hendrickx, S. Lalitha Devi, A. Branco & R. Mitkov (Eds.), *Anaphora Processing and Applications, DAARC 2011 Revised Selected Papers, LNAI-Lecture Notes on Artificial Intelligence 7099* (pp. 184–197). Springer-Verlag. https://doi.org/10.1007/978-3-642-25917-3_16

Sandoval, T. C., Gollan, T. H., Ferreira, V. S., & Salmon, D. P. (2010). What causes the bilingual disadvantage in verbal fluency?: The dual-task analogy. *Bilingualism: Language and Cognition, 13*, 231–252. https://doi.org/10.1017/S1366728909990514

Schlesewsky, M., & Bornkessel, I. (2004). On incremental interpretation: Degrees of meaning accessed during sentence comprehension. *Lingua*, *114*, 1213–1234. https://doi.org/10.1016/j.lingua.2003.07.006

Schwartz, M. F., & Hodgson, C. (2002). A new multiword naming deficit: Evidence and interpretation. *Cognitive Neuropsychology, 19*(3), 263–288. https://doi.org/10.1080/02643290143000187

Schwartz, M. F., Saffran, R. B., Fink, J. L. M., & Martin, N. (1994) Mapping therapy: A treatment programme for agrammatism. *Aphasiology*, *8*(1), 19–54. https://doi.org/10.1080/02687039408248639

Schwartz, M. E, Saffran, E. M., & Marin, O. S. M. (1980). The word order problem in agrammatism. I. Comprehension. *Brain and Language*, *10*, 249–262. https://doi.org/10.1016/0093-934X(80)90055-3

Shetreet, E., & Friedmann, N. (2012). Stretched, jumped, and fell: An fMRI investigation of reflexive verbs and other intransitives. *NeuroImage*, *60*(3), 1800–1806. https://doi.org/10. 1016/j.neuroimage.2012.01.081

Shetreet, E., Friedmann, N., & Hadar, U. (2010). The neural correlates of linguistic distinctions: Unaccusative and unergative verbs. *Journal of Cognitive Neuroscience*, 22, 2306–2315. https://doi.org/10.1162/jocn.2009.21371

Slevc, R. (2023). Grammatical encoding. In R. J. Hartsuiker, & K. Strijkers (Eds.), *Language Production* (pp. 4–31). Routledge. https://doi.org/10.4324/9781003145790-2

Snodgrass, J. G., & Vanderwart, M. (1980). A standardized set of 260 pictures: Norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Human Learning and Memory*, *6*, 174–215. http://doi.org/10.1037//0278-7393.6.2.174

Sorace, A. (2000). Gradients in Auxiliary Selection with Intransitive Verbs. *Language* 76(4), 859–90. https://doi.org/10.2307/417202.

Spelke, E. S., & Kinzler, K. D. (2007). Core knowledge. *Developmental science*, *10*(1), 89–96. https://doi.org/10.1111/j.1467-7687.2007.00569.x

Stemberger, J. P. (1985). An interactive activation model of language production. In A. W. Ellis (Ed.), *Progress in the psychology of language*, *Vol. 1* (pp. 143–186). Erlbaum.

Sung, J. E. (2016). The Effects of Verb Argument Complexity on Verb Production in Persons with Aphasia: Evidence from a Subject-Object-Verb Language. *Journal of Psycholinguistic Research*, *45*(2), 287–305. https://doi.org/10.1007/s10936-014-9346-y

Thompson, C. K. (2003). Unaccusative verb production in agrammatic aphasia: the argument structure complexity hypothesis. *Journal of Neurolinguistics, 16*(2–3), 151–167. https://doi.org/10.1016/S0911-6044(02)00014-3

Thompson, C. K. (2011). *The Northwestern Assessment of Verbs and Sentences*. Northwestern University.

Thompson, C. K., Faroqi-Shah, Y., & Lee, J. (2015). Models of sentence production. In A. E. Hillis (Ed.), *The handbook of adult language disorders* (pp. 328–354). Psychology Press.

Thompson, C. K., Lange, K. L., Schneider, S. L., & Shapiro, L. P. (1997). Agrammatic and non-brain-damaged subjects' verb and verb argument structure production. *Aphasiology*, *11*(4), 473–490. http://dx.doi.org/10.1080/02687039708248485

Thompson, C. K., Lukic, S., King, M. C., Mesulam, M-M., & Weintraub, S. (2012). Verb and noun deficits in stroke-induced and primary progressive aphasia: The Northwestern Naming Battery. *Aphasiology*, *26*, 632–655. https://doi.org/10.1080/02687038.2012.676852

Thompson, C. K., & Meltzer-Asscher, A. (2014). Neurocognitive mechanisms of verb argument structure processing. In A. Bachrach, I. Roy & L. Stockall (Eds.), *Structuring the argument: Multidisciplinary research on verb argument structure* (pp. 141–168). John Benjamins.

Thompson, C. K., & Shapiro, L. P. (2005). Treating agrammatic aphasia within a linguistic framework: Treatment of Underlying Forms. *Aphasiology*, *19*(10–11), 1021–1036. https://doi.org/10.1080/02687030544000227

Thompson, C. K., Shapiro, L. P., Li, L., & Schendel, L. (1995). Analysis of verbs and verb-argument structure: A method for quantification of aphasic language production. *Clinical aphasiology*, *23*, 121–140. http://aphasiology.pitt.edu/id/eprint/195

Tollan, R., Massam, D., & Heller, D. (2019). Effects of Case and Transitivity on Processing Dependencies: Evidence from Niuean. *Cognitive Science, 43*(6), 1–14. https://doi.org/10.1111/cogs.12736

Torrego, E. (1989). Unergative-unaccusative alternations in Spanish. *MIT Working Papers in Linguistics, 10*, 253–272.

Traxler, M. J., Morris, R. K., & Seely, R. E. (2002). Processing subject and object relative clauses: Evidence from eye movements. *Journal of Memory and Language*, *47*, 69–70. https://doi.org/10.1006/jmla.2001.2836

Turkstra, L. S., & Holland, A. L. (1998). Assessment of syntax after adolescent brain injury: effects of memory on test performance. *Journal of speech, language, and hearing research: JSLHR*, *41*(1), 137–149. https://doi.org/10.1044/jslhr.4101.137

van Valin, R. (1990). Semantic parameters on split intransitivity. *Language*, 66, 221–260. https://doi.org/10.2307/414886

Venkatesh, M., Edwards, S., & Saddy, J. D. (2012). Production and comprehension of English and Hindi in multilingual transcortical aphasia. *Journal of Neurolinguistics, 25*(6), 615–629. https://doi.org/10.1016/j.jneuroling.2011.10.003

Wagner, L., & Lakusta, L. (2009). Using Language to Navigate the Infant Mind. *Perspectives on psychological science: A journal of the Association for Psychological Science*, *4*(2), 177–184. https://doi.org/10.1111/j.1745-6924.2009.01117.x

Waller, M. R., & Darley, F. L. (1978). The influence of context on the auditory comprehension of paragraphs by aphasic subjects. *Journal of Speech & Hearing Research, 21*(4), 732–745. https://doi.org/10.1044/jshr.2104.732

Wambaugh, J.L., Mauszycki, S., & Wright, S. (2014) Semantic feature analysis: Application to confrontation naming of actions in aphasia. *Aphasiology*, *28*(1), 1–2. https://doi.org/10.1080/02687038.2013.845739

Webster, J., Franklin, S., & Howard, D. (2004). Investigating the sub-processes involved in the production of thematic structure: an analysis of four people with aphasia. *Aphasiology, 18*, 47–68. https://doi.org/10.1080/02687030344000481

Webster, J., & Gordon, B. (2009) Contrasting therapy effects for verb and sentence processing difficulties: A discussion of what worked and why. *Aphasiology*, *23*(10), 1231–1251. https://doi.org/10.1080/02687030802246291

Williams, E. (1981). Argument structure and Morphology. *The Linguistic Review*, *1*, 81–114. https://doi.org/10.1515/tlir.1981.1.1.81

Williams, S. E., & Canter, G. J. (1982). The influence of situational context on naming performance in aphasic syndromes. *Brain and Language, 17*(1), 92–106. https://doi.org/10.1016/0093-934X(82)90007-4

Williams, S. E., & Canter, G. J. (1987). Action-naming performance in four syndromes of aphasia. *Brain and language*, *32*(1), 124–136. https://doi.org/doi.org/10.1016/0093-934x(87)90120-9

Wilshire, C. E., & McCarthy, R. A. (2002). Evidence for a context-sensitive word retrieval disorder in a case of nonfluent aphasia. *Cognitive Neuropsychology, 19*(2), 165–186. https://doi.org/10.1080/02643290143000169

Youse, K. M., & Coelho, C. A. (2005). Working memory and discourse production abilities following closed-head injury. *Brain injury*, *19*(12), 1001–1009. https://doi.org/10.1080/02699050500109951

Zaenen, A. (1993). Unaccusativity in Dutch: Integrating Syntax and Lexical Semantics. In: J. Pustejovsky, (Ed.), *Semantics and the Lexicon. Studies in Linguistics and Philosophy*, *Vol. 49* (pp. 317–335). Springer https://doi.org/10.1007/978-94-011-1972-6_9

Zawiszewski, A., Gutiérrez, E., Fernández, B., & Laka, I. (2011). Language distance and non-native syntactic processing: Evidence from event-related potentials. *Bilingualism: Language and Cognition*, *14*(3), 400–411. https://doi:10.1017/S1366728910000350

Zawiszewski, A., & Laka, I. (2020). Bilinguals processing noun morphology: Evidence for the Language Distance Hypothesis from event-related potentials. *Journal of Neurolinguistics*, *55.* https://doi.org/10.1016/j.jneuroling.2020.100908

Zingeser, L. B., & Berndt, R. S. (1988). Grammatical class and context effects in a case of pure anomia: Implications for models of language production. *Cognitive Neuropsychology*, *5*(4), 473–516. https://doi.org/10.1080/02643298808253270

Zingeser, L. B., & Berndt, R. S. (1990). Retrieval of nouns and verbs in agrammatism and anomia. *Brain and Language*, *39*, 14–32. https://doi.org/10.1016/0093-934X(90)90002-X

Zwaan, R. A. (1999). Situation Models: The Mental Leap into Imagined Worlds. *Current Directions in Psychological Science*, *8*(1), 15–18. https://doi.org/10.1111/1467-8721.00004

Appendices

Appendix A

Appendix A.1. Diagnostic tests. 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*	-

Appendix A.2. Stimuli. The Spanish and Basque 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.

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)

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)

[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.

Appendix A.3. Psycholinguistic variables**.** 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

Appendix A.4. Grammar tests. 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.

Appendix A.5. Subject omission analysis. In this exploratory analysis, we tested how subject omission in the sentence production task affects the SOTs in Spanish (A.5a) and Basque (A.5b). The 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.

A.5a. Spanish SOT analysis: comparison of the model with the verb type only and with the verb type plus subject omission; subject omission did not improve the model fit.

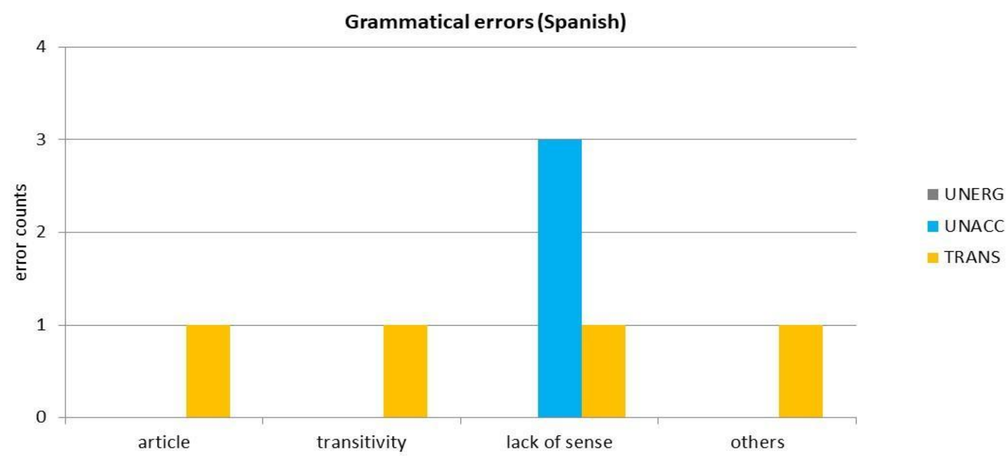
model 1	**lmer** (log(SOT) ~ verb type (1|subject) + (1|item))	
model 2	**lmer** (log(SOT) ~ verb type + subject omission + (1|subject) + (1|item))	
anova	**Chisq**	***p*-value**
	0.573	.449

A.5b. Basque SOT analysis: comparisons of the model with the verb type only, with the verb type plus subject omission and their interaction; subject omission improved the model fit but there was no interaction with verb type (this suggests that 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).

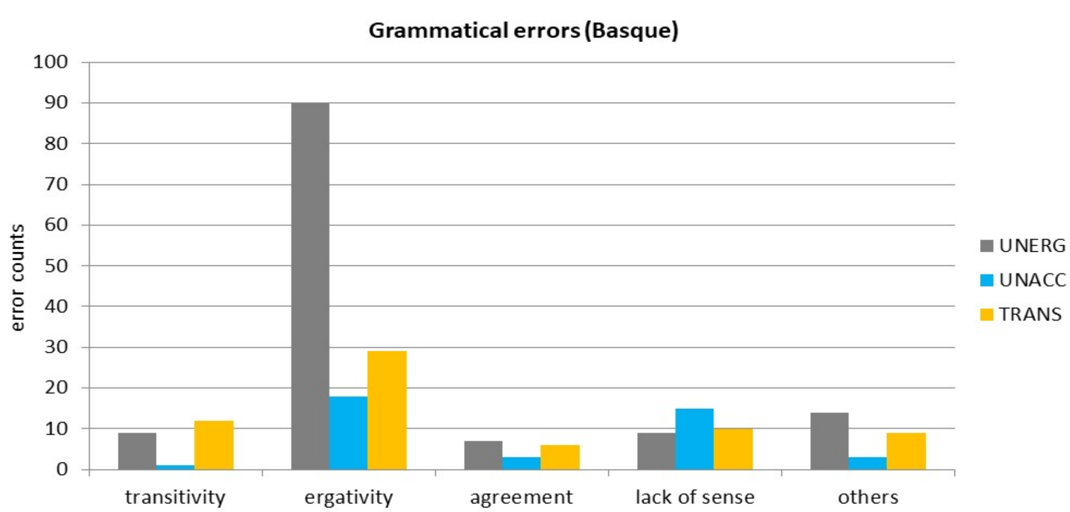
model 1	**lmer** (log(SOT) ~ verb type + (1|subject) + (1|item))	
model 2	**lmer** (log(SOT) ~ verb type + subject omission + (1|subject) + (1|item))	
anova	**Chisq**	***p*-value**
	19.277	1.131e-05 *
model 2	**lmer** (log(SOT) ~ verb type + subject omission + (1|subject) + (1|item))	
model 3	**lmer**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

Appendix A.6. Grammatical errors

A.6a. 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. (Note 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.)



A.6b. 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. (Note that 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.)



Appendix A.7. Exploratory analyses

A.7a. Results of the exploratory analysis of error rates in the Basque sentence production task; the main model was compared to more complex models with additional individual difference variables for i) mean exposure to Spanish[1] (= exposure_SP), ii) grammatical proficiency[2] (= prof_BQ), and (if significant) their interaction with the verb type.[3] 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 **model 1**	**glmer** (error ~ verb type + (1 + verb type|subject) + (1|item)) **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 **model 1a**	**glmer** (error ~ verb type + exposure_SP + (1 + verb type|subject) + (1|item)) **glmer** (error ~ verb type * exposure_SP + (1 + verb type|subject) + (1|item))			
anova (model 1, model 1a)	**Chisq** 0.851	***p*-value** .653		
		Exposure & Proficiency		
model 1 **model 2**	**glmer** (error ~ verb type + exposure_SP + (1+ verb type |subject) + (1|item)) **glmer** (error ~ verb type + exposure_SP + prof_BQ + (1+ verb type|subject) + (1|item))			
anova (model1, model2)	**Chisq** 6.969	***p*-value** .008 **		
model 2	**glmer** (error ~ verb type + exposure_SP + 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 **model 2a**	**glmer** (error ~ verb type + exposure_SP + prof_BQ + (1+ verb type |subject) + (1|item)) **glmer** (error ~ verb type * prof_BQ + exposure_SP + (1+ verb type |subject) + (1|item))			
anova (model2, model2a)	**Chisq** 0.918	***p*-value** .632		

A.7b. The results of the exploratory analysis of speech onset times (SOTs) in the Basque sentence production task; 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+ verb type|subject) + (1|item))	
model 1	**lmer** (log(SOT) ~ verb type + exposure_BQ + (1+ verb type|subject) + (1|item))	
anova (model 0, model 1)	**Chisq**	***p*-value**
	6.059	.4166

	Proficiency	
model 0	**lmer** (log(SOT) ~ verb type + (1+ verb type |subject) + (1|item))	
model 2	**lmer** (log(SOT) ~ verb type + prof_BQ + (1+ verb type |subject) + (1|item))	
anova (model 0, model 2)	**Chisq**	***p*-value**
	6.336	.3866

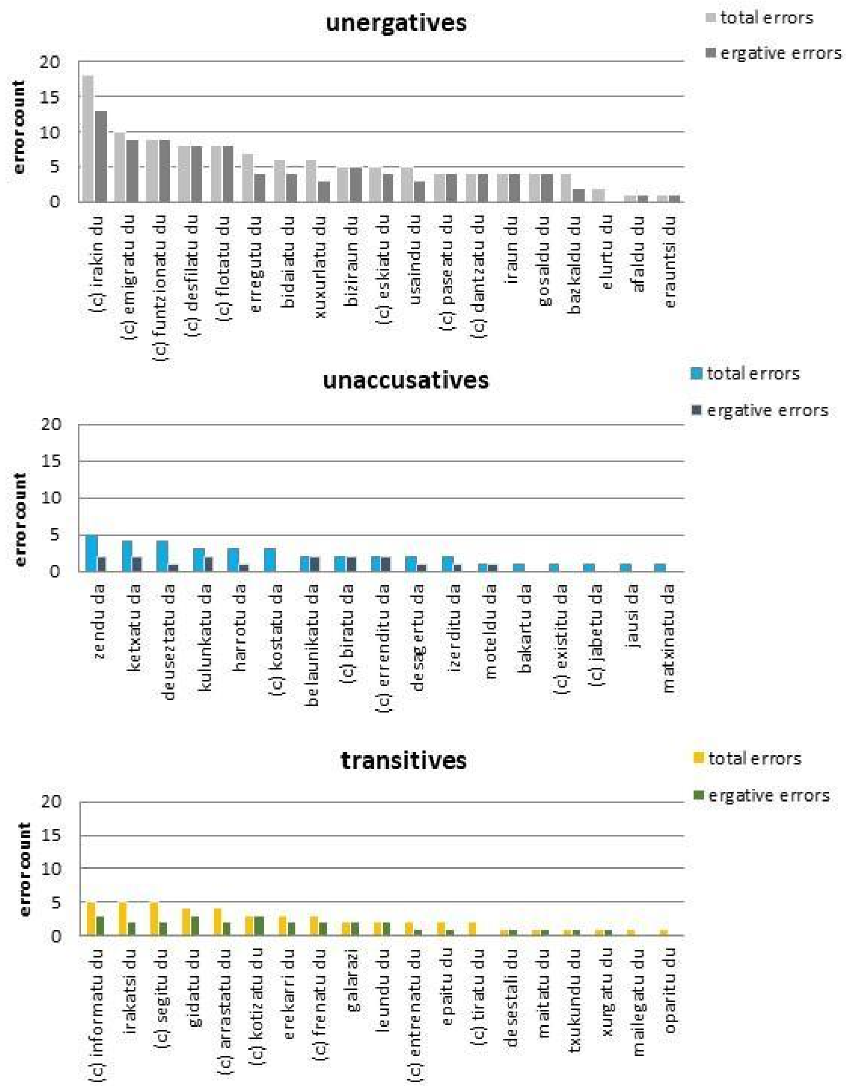
[1] To compute exposure we extracted self-reported exposure scores from the participants' database, where daily usage (%) of Basque/Spanish in writing, speaking, reading, and listening was reported. Overall, participants experienced more exposure to Spanish than Basque (Spanish: mean = 51%, SD = 17, 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 (Appendix A.4.).

[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 adding language exposure and proficiency to the best fitted model so as to demonstrate that their inclusion did not cancel out the effect of verb type.

Appendix A.8. Grammatical errors by item: Basque. Error count for each item.[1] Light gray/color bars represent the total number of grammatical errors produced for each verb within the three verb groups; dark gray bars represent ergative case errors (e.g., ergative case marking omissions), verbs marked with (c) prefixes indicate cognate verbs as determined by Levenshtein distance.



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[1] Some unergative cognates (e.g., *desfilatu / to parade*, *emigrate / to emigrate*, *flotatu / to float*, *futzionatu / to function*) were more susceptible to ergative case marking omissions than others that elicited error rates comparable to the non-cognates (e.g., *eskiatu / to ski*, *paseatu / to stroll*). Cognates in the transitive group (e.g., *tiratu du / pull*) were not particularly problematic, suggesting that cognate status *per se* was not responsible for the tendency to omit ergative case marking. The most problematic verb in the unergative group, *irakin / to boil* is not a cognate, however, its Spanish translational equivalent *hervir* is typically classified as unaccusative (e.g., Perlmutter, 1978). The same is true for the verb *flotatu* classified as unergative in Basque but typically considered unaccusative in Spanish. Although unaccusative-unergative classification of translational equivalents often varies across languages, this mismatch could have resulted in competition between unergative and unaccusative readings of these verbs, impacting the results.

Appendix A.9. Interaction analysis. To test if Spanish and Basque elicit differential speech onset times (SOTs), we conducted an interaction analysis between verb type and language. 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.

Appendix B

Appendix B.1. Stimuli. Verbs used as stimuli in Basque and Spanish.

Basque

	unergatives	**unaccusatives**	**transitives**
1	arrantzatu (fish)	haserretu (get angry)	josi (sew)
2	bidaiatu (travel)	biratu (spin)	ureztatu (water)
3	patinatu (skate)	irristatu (slip)	tiratu (pull)
4	amestu (dream)	belaunikatu (kneel)	bultzatu (push)
5	dantzatu (dance)	izoztu (freeze)	jaurti (throw)
6	eskalatu (climb)	urtu (melt)	konpondu (fix)
7	nabigatu (sail)	erori (fall)	moztu (cut)
8	eskiatu (ski)	esnatu (wake up)	plantxatu (iron)
9	pentsatu (think)	hondoratu (sink)	margotu (paint)

Spanish

	unergatives	**unaccusatives**	**transitives**
1	escalar (climb)	sonar (ring)	tender (hang)
2	nadar (swim)	quemarse (burn)	cantar (sing)
3	ladrar (bark)	tropezar (trip)	beber (drink)
4	llorar (cry)	hervir (boil)	aspirar (vacuum)
5	correr (run)	resbalarse (slip)	secarse (blow-dry)
6	reír (laugh)	caer (fall)	morder (bite)
7	aplaudir (clap)	florecer (bloom)	barrer (sweep)
8	saltar (jump)	chocar (crash)	cocinar (cook)
9	volar (fly)	despegar (take off)	pintar (paint)

Appendix B.2. Psycholinguistic variables. Statistical comparisons for controlled psycholinguistic variables across verb groups: a) visual complexity; b) frequency; c) length; and d) Levenshtein distance (to control for cognates across languages).

	Basque		**Spanish**	
	F-value	*p*-value	F-value	*p*-value
visual complexity	0.62	.55	0.12	.89
frequency	0.91	.41	0.84	.44
length	3.21	.06	1.53	.24
	F-value	*p*-value		
Levenshtein distance	1.40	.27	-	-

Appendix B.3. Task procedures

Action naming task
In this task, participants were asked to name the actions depicted by visual stimuli on the screen with the most suitable verb in the infinitive form (e.g., Spanish *correr* / *to speak* or Basque *erori* / *to fall*). The participants were provided with four examples of various verb types to practice and their responses were corrected if they failed to produce a verb, a one-word response or other than the infinitive verb form. After the practice, each participant was prompted to ask any clarification questions before the experimental part started.

The total of 27 experimental items were presented in a list with random order. Each trial consisted of a fixation cross presented for 1500 ms, followed by a visual stimulus presented for 3000 ms, during which the oral response was recorded. While the next fixation cross appeared, the microphone was still recording for 500 more ms before being reset. The resulting time limit of 3500 ms to respond was introduced to increase task demands and make lexical access more automatic/less controlled processes. Trials appeared on the screen automatically without any key press required.

Oral responses were transcribed verbatim and scored as either correct or incorrect. An item was scored as correct if the produced verb was either identical with the target verb or different, but semantically acceptable given the visual stimulus (e.g., *chew / masticar* would be an acceptable substitute for *bite / morder*). A different verb form (e.g., inflected form *falls* or *-ing* form *falling*) and longer than one-word response (e.g., *tender la ropa / to hang the laundry*) were also scored as correct. In trials in which a correct and incorrect response was provided, only the correct response was scored. A response was scored as incorrect if it was of a different word class (e.g., a noun referring to the agent of the action), was not in the target language, was semantically inappropriate (e.g., *cry* in place of *laugh*) or if no response was provided within the time limit.

Sentence elicitation task
In this task, participants were asked to describe the actions depicted by visual stimuli on the screen in a full sentence including a subject, a verb and an object, if needed. They were encouraged to provide their oral response as accurately and fast as possible and use *pretérito perfecto compuesto* (*e.g., el perro ha ladrado* / *the dog has barked*) and its Basque equivalent (e.g., *neska erori da* / *the girl has fallen*) to eliminate response variability and irregular verb forms associated with other tenses in Spanish but also to encourage the use of ergative case marking in Basque. Participants were then provided with four examples to practice and their responses were corrected if they failed to produce a full sentence or the requested sentence form.

The same 27 action pictures were presented in the same manner and random order as in the action naming task. Each trial started with a fixation cross presented for 1500 ms, followed by a visual stimulus presented for 5000 ms, during which the oral response was recorded. While the next fixation cross appeared, the microphone was reset, which resulted in the response time limit of 5000 ms. Trials appeared on the screen automatically without any key press required.

The oral responses were all transcribed verbatim and scored as correct if a sentence was produced including at least a subject and a verb and if this sentence was semantically appropriate given the visual stimulus (e.g., *the flower has opened / la flor se ha abierto* would be an acceptable substitute for *the flower has bloomed / la flor ha florecido*). Trials in which participants made more than one attempt to produce a full sentence but produced the correct sentence in the end were also scored as correct. A response was scored as incorrect in cases where a subject or a verb was missing, where incomplete or no response was provided or where grammatical errors were produced.

Verb-picture verification task

In this task, participants were asked to look at the pictures of actions presented on the screen and decide if the auditory stimulus accompanying each picture corresponds to the picture or not by pressing a corresponding key as fast and as accurately as possible.

Auditory stimuli consisted of 27 verbs recorded in isolation in their infinitive form. These recordings were used to create both congruent and incongruent trials (i.e., trials in which the verb matched or mismatched the depicted action). The auditory verb on incongruent trials was always semantically unrelated and started with a different phoneme to the depicted verb.

Participants were first asked to complete four practice items, two in congruent and two in incongruent condition. After prompting the participant to ask any clarification questions, the experimental part started. The total number of 54 items (27 congruent and 27 incongruent) was divided into two lists counterbalanced for verb type and condition. Each list was presented in a separate session in a random item order so that each participant heard all verbs paired with congruent and incongruent images, but no visual or auditory stimulus was repeated within one session.

Each trial started by a fixation cross that appeared on the screen for 500 ms. Then, a visual stimulus was shown and 500 ms later, an auditory stimulus in congruent or incongruent condition was presented via headphones. The visual stimulus remained on the screen until a key press indicating the response.

Sentence-picture verification task

In this task, participants followed the same procedure as in the verb-picture verification task. The only difference were the presented auditory stimuli, which were full sentences either congruent or incongruent with the visual stimuli.

The auditory stimuli for this task consisted of 27 congruent and 27 incongruent sentences recorded for every language. Every sentence consisted of a subject, a verb from the final stimuli list and either an object for transitive sentences or a complemental phrase (i.e., adjectival phrase, prepositional phrase or a complement) for intransitive sentences. All the lexical items used as subjects, verbs and objects/complemental phrases were controlled for logarithmic frequency and all the lexical items and sentences were controlled for length in letters and syllables. On congruent trials, the verb in the auditorily presented sentence described the depicted action in the image. On incongruent trials the verb was a different verb of the same type from the final stimuli list, which was semantically unrelated and started with a different phoneme to the depicted verb. The sentences were presented in *pretérito perfecto compuesto (e.g., el chico ha corrido muy rápido / the guy has run very fast*) and its Basque equivalent (e.g., *emakumea airean erori da / the woman has fallen through the air*).

Participants were first asked to complete four practice items, two in congruent and two in incongruent condition. After prompting the participant to ask any clarification questions, the experimental part started.

Each trial consisted of a fixation cross that appeared on the screen for 500 ms. Then, a visual stimulus was shown and 500 ms later the auditory stimulus (either a congruent or an incongruent sentence) was presented via headphones. The visual stimulus remained on the screen until the key was pressed, indicating the participant's response.

Appendix C

Appendix C.1. LEAP-Q results (Marian et al., 2007) for PWA1, PWA2 (pre/post onset) and the means (SD) of their controls in both languages.

	English		Spanish		Basque		Spanish	
	PWA1 pre/post onset	controls (SD)	PWA1 pre/post onset	controls (SD)	PWA2 pre/post onset	controls (SD)	PWA2 pre/post onset	controls (SD)
Critical age (years)								
start acquiring	13	10.3 (4.0)	0	0.3 (0.6)	0	0.5 (0.7)	3	3.0 (1.4)
fluent speaker	15	18.3 (6.1)	--	6.7 (2.9)	3	3.3 (1.1)	5	7.0 (2.8)
start reading	13	10.3 (4.0)	6	4.7 (0.6)	5	5.0 (0)	6	6.5 (0.7)
fluent reader	15	16.7 (3.5)	--	6.7 (2.5)	7	8.5 (2.1)	7	11.0 (1.4)
living in country	47	46.3 (11.0)	13	17.7 (8.8)	21	21.0 (0)	21	21.0 (0)
Proficiency (scale 0–10)								
speaking	10 / 3	9.7 (0)	10 / 4	10 (0)	9 / 7	9.0 (1)	9 / 8	8.7 (1.2)
understanding	10 / 3	10.0 (0)	10 / 7	10 (0)	9 / 7	9.7 (0.6)	9 / 8	9.0 (1.0)
Current exposure overall (%)								
total	30	46.7 (25.2)	70	53.3 (25.2)	70	70 (10)	30	25.0 (10)
Current exposure to (scale 0–10)								
friends	10	10.0 (0)	10	8.2 (1.6)	9	7.7 (2.3)	7	5.0 (4.6)
family	10	7.3 (4.6)	10	9.7 (0.6)	9	9.3 (0.6)	7	6.0 (4.4)
reading	4	9.7 (0.6)	10	5.3 (2.5)	0	5.3 (2.3)	0	8.3 (0.6)
TV	10	9.3 (1.2)	10	2.3 (2.5)	3	4.3 (2.3)	9	9.0 (1.0)
music/radio	10	8.7 (2.3)	10	4.3 (3.2)	0	7.0 (1.0)	0	7.0 (3.6)
Accent (scale 0–10)								
self-estimate	0 / 0	5.3 (3.5)	0	0 (0)	0 / 0	0	0 / 0	4.3 (0.6)
other's estimate	0 / 0	6.0 (3.6)	0	0 (0)	0 / 0	0	0 / 0	4.0 (2.8)

Appendix C.2. BSWQ results (Rodriguez-Fornells et al., 2012) for PWA1, PWA2 and the means (SD) of their controls in both languages (verbal responses have been transferred to numeric values: never = 0, very rarely = 1, occasionally = 2, frequently = 3, always = 4); L1 and L2 refer to the languages with respect to the order of acquisition.

	Questions	PWA1	controls (SD)	PWA2	controls (SD)
1.	I cannot recall some L1 words when I am speaking in L1.	1	2.3 (0.6)	2	0.7 (0.6)
2.	I cannot recall some L2 words when I am speaking in L2.	2	1.7 (0.6)	2	1.7 (0.6)
3.	I tend to switch languages during a conversation.	4	3.0 (1.0)	3	1.7 (1.2)
4.	When I cannot recall a word in L1, I tend to immediately produce it in L2.	4	3.3 (0.6)	3	3.0 (1.0)
5.	When I cannot recall a word in L2, I tend to immediately produce it in L1.	1	3.3 (0.6)	3	3.7 (0.6)
6.	I do not realize when I switch the language during a conversation.	4	1.7 (1.2)	2	0.7 (0.6)
7.	When I switch languages, I do it consciously.	1	3.3 (1.2)	3	2.7 (1.5)
8.	It is difficult for me to control the language switches during a conversation.	2	2.0 (1.7)	2	1.0 (0)
9.	I sometimes produce the L2 word faster when I am speaking in L1.	2	1.7 (0.6)	2	1.3 (0.6)
10.	I sometimes produce the L1 word faster when I am speaking in L2.	1	2.7 (0.6)	3	2.3 (0.6)
11.	There are situations in which I always switch between these two languages.	4	3.0 (1.0)	2	1.7 (1.2)
12.	There are certain topics or issues for which I normally switch between these two languages.	4	3.0 (0)	2	2.0 (1.0)

Appendix C.3. CETI results (Lomas et al., 1989) for PWA1 and PWA2 (slider responses have been transferred to numeric values on a 0–10 scale where 0 = not at all able; 10 = as able as before stroke).

	Rate your ability (0-10) at:	PWA1	PWA2
1.	Getting somebody's attention.	10	7
2.	Getting involved in group conversations that are about you.	10	3.5
3.	Giving yes and no answers appropriately.	5	9
4.	Indicating that you understand what is being said to you.	5	7.5
5.	Having a one-on-one conversation with a family member.	10	7
6.	Saying the name of someone who is in front of you.	10	10
7.	Having a spontaneous conversation.	5	3.5
8.	Starting a conversation with people who are not close family.	5	3.5
9.	Understanding writing.	10	9
10.	Participating in a conversation with strangers.	5	3.6
	Average (SD)	**7.5 (2.6)**	**6.4 (2.6)**

Appendix C.4. Stimuli. Verbs used as stimuli for PWA1, PWA2 and controls across all tasks.

English

	unergatives	unaccusatives	transitives
1	snore	fall	pour
2	laugh	rot	kick
3	shiver	melt	throw
4	crawl	hang	push
5	kneel	spin	mail
6	run	burn	slap
7	wave	sink	stir
8	sweat	freeze	vacuum
9	wink	boil	water

Latin-American Spanish

	unergatives	unaccusatives	transitives
1	escalar (climb)	sonar (ring)	colgar (hang)
2	nadar (swim)	quemarse (burn)	cantar (sing)
3	ladrar (bark)	tropezar (trip)	tomar (drink)
4	llorar (cry)	hervir (boil)	aspirer (vacuum)
5	correr (run)	resbalarse (slip)	secar (blow-dry)
6	reir (laugh)	caer (fall)	morder (bite)
7	aplaudir (clap)	florecer (bloom)	barrer (sweep)
8	saltar (jump)	chocar (crash)	cocinar (cook)
9	volar (fly)	despegar (take off)	pintar (paint)

Basque

	unergatives	unaccusatives	transitives
1	arrantzatu (fish)	haserretu (get angry)	josi (sew)
2	bidaiatu (travel)	biratu (spin)	ureztatu (water)
3	patinatu (skate)	irristatu (slip)	tiratu (pull)
4	amestu (dream)	belaunikatu (kneel)	bultzatu (push)
5	dantzatu (dance)	izoztu (freeze)	jaurti (throw)
6	eskalatu (climb)	urtu (melt)	konpondu (fix)
7	nabigatu (sail)	erori (fall)	moztu (cut)
8	eskiatu (ski)	esnatu (wake up)	plantxatu (iron)
9	pentsatu (think)	hondoratu (sink)	margotu (paint)

Spanish (Peninsular)

	unergatives	unaccusatives	transitives
1	escalar (climb)	sonar (ring)	tender (hang)
2	nadar (swim)	quemarse (burn)	cantar (sing)
3	ladrar (bark)	tropezar (trip)	beber (drink)
4	llorar (cry)	hervir (boil)	aspirer (vacuum)
5	correr (run)	resbalarse (slip)	secarse (blow-dry)
6	reir (laugh)	caer (fall)	morder (bite)
7	aplaudir (clap)	florecer (bloom)	barrer (sweep)
8	saltar (jump)	chocar (crash)	cocinar (cook)
9	volar (fly)	despegar (take off)	pintar (paint)

Appendix C.5. Psycholinguistic variables. The F- and *p*-values for comparisons of unergative, unaccusatives and transitive verb groups across all languages are reported for all controlled variables in our visual stimuli (visual complexity) and verbal stimuli (logarithmic frequency, length in syllables and cognate status measured by Levenshtein distance within each language pair).

	English		**Latin-American Spanish**		**Basque**		**Peninsular Spanish**	
	F-value	*p*-value	F-value	*p*-value	F-value	*p*-value	F-value	*p*-value
Vis. complexity	0.91	.41	0.28	.75	0.62	.55	0.12	.89
Frequency	0.80	.46	0.59	.56	0.91	.41	0.84	.44
Length	1.09	.35	2.00	.16	3.21	.06	1.53	.24
Levenshtein distance	0.19	.83	-	-	1.40	.27	-	-

Appendix C.6. Task procedures

1. Action naming task

In this task, participants were asked to name the actions depicted by visual stimuli on the screen in one word. The experimenter provided one example of an expected one-word response in an infinitive form (e.g., Spanish: *caer* / *to fall*; Basque: *erori* / *to fall*) or a bare infinitive in English (e.g., *fall*). The participant was then provided with three examples of various verb types to practice and their responses were corrected if they failed to produce a verb, a one-word response or a verb form other than the infinitive (or bare infinitive in English). After the practice, the participant was prompted to ask any clarification questions and once making sure they understood the task, the experimental part started.

The 27 experimental items were presented in a list in a semi-random order (i.e., a maximum of two verbs of the same type or three intransitive verbs could appear in a sequence). During the task, the experimenter was instructed to prompt the participant once if they failed to produce a verb by directing their attention to the action. If the participant produced more than one word or a verb in a different form than the infinitive, the experimenter accepted the response but repeated it in the requested form.

All the oral responses were transcribed verbatim and scored as either correct or incorrect. An item was scored as correct if the produced verb was either identical with the target verb or different but semantically acceptable given the visual stimulus (e.g., *chew* would be an acceptable substitute for *bite*). A different verb form (e.g., inflected form *falls* or *-ing* form *falling*) and longer than one-word response (e.g., *a man fell*) were also scored as correct. In trials in which a correct and incorrect response was provided, only the correct response was scored. A response was scored as incorrect if it was of a different word class (e.g., a noun referring to the agent of the action), was not in the target language, was semantically inappropriate (e.g., *cry* in place of *laugh*), or if no response was provided.

2. Sentence elicitation task

In this task, participants were asked to describe the action depicted by visual stimuli on the screen in a full sentence including a subject, a verb and an object, if needed. The experimenter provided one example of an expected response (e.g., *the boy is cutting the paper*) and directed attention to all the constituents used in the sentence one by one, pointing out the subject, the action verb and the object. The participant was then provided with three examples of different verb types to practice and their responses were corrected if they failed to produce a full sentence. They were also encouraged to use the present continuous tense in English and its equivalent in Latin-American Spanish (e.g., *la chica está abriendo la ventana / the girl is opening the window*) or present perfect tense in Peninsular Spanish (e.g., *la chica ha abierto la ventana* / *the girl has opened the window*) and its Basque equivalent (e.g., *gizonak autoa gidatu du* / *the man has driven the car*). The tense selection in Basque-Spanish bilinguals was motivated by our interest in performance on auxiliary production in Basque, which can only be contrasted in a non-progressive tense. In the case of Spanish-English bilinguals, the present continuous tense was encouraged as it is generally more appropriate in the context of picture description in English. After the practice, the participant was prompted to ask any clarification questions and once having understood the task, the experimental part started.

The same 27 action pictures were presented in the same manner and semi-random order as in the action naming task.

During the task, the experimenter prompted the participant once if they failed to produce a full sentence (e.g., they would prompt a full sentence response in cases of one-word responses or point attention to the omitted obligatory object in transitive actions). The use of alternative tense forms was not corrected during the experimental part.

The oral responses were all transcribed verbatim and scored as correct if a sentence was produced including at least a subject and a verb and if this sentence was semantically appropriate given the visual stimulus (e.g., *the man is saying bye* would be an acceptable substitute for *the man is waving*). Any tense form was scored as correct. Phonological paraphasia (e.g., "*the boat iks tinking"* instead of *the boat is sinking*) was also not penalized, provided the sentence was understandable. Trials in which participants made more than one attempt to produce a full sentence but finally produced the correct sentence were also scored as correct. A response was scored as incorrect in cases where a subject or a verb was missing (e.g., *gizona e… autoa* / *the man e… the car*), where a verbal paraphasia was produced resulting in a semantically incorrect sentence (e.g., *the snowman is shivering* in place of *the snowman is melting*), where code switching occurred within a sentence resulting in a neologism (e.g., *gizona* ***regatzen*** *ari da* / *the man is* ***regating****:* a neologism created from a stem in one language combined with an ending from another language) or where no response was provided. Any grammatical errors produced (e.g., *the girl fall down*) were marked and counted but the sentences were not scored as incorrect due to their presence as long as the target verb was produced.

3. Story elicitation task

In this task, participants were instructed to look at four images depicting a short story and tell this story with a beginning, middle and end. Then, the experimenter showed one example and provided an expected response (e.g., *There is a frozen pond with a hole in the ice. There is a boy and a girl and they skate towards the hole. Under the ice there is a fish and the boy is thinking. They get a stick and they fish in the hole.*). The participant was provided with two examples to practice. They were encouraged to say more if they failed to produce at least one to two sentences to tell a story. After the practice, the participant could ask any clarification questions before the task started. If the participant failed to produce at least one full sentence to describe a story during the experimental part, the experimenter was instructed to encourage the speaker once to tell a little more.

The stimuli in this task were split into two counterbalanced sets and every participant was shown only one set during each session. There were eight picture stories in the first list and seven in the second list (15 items in total) presented in the same semi-random order (i.e., a maximum of two identical verb types and a maximum of three intransitive verb types could appear in a row).

Every story was transcribed verbatim and segmented based on the image prompts. The segments were scored as correct if they included the verb that the picture was intended to elicit or a semantically related verb or phrase that matched the visual stimulus. The segment was scored as incorrect if the segment was omitted from the narrative or if an inappropriate verb or neologism was produced instead (e.g., *mopiando* in place of *fregando:* a neologism formed from the English verb *to mop*). Any grammatical errors produced (e.g., *the two mens are sinking*) were marked as ungrammatical but segments that included them were not scored as formally incorrect (i.e., it was not considered as failed verb retrieval).

4. Verb-picture verification task
In this task, participants were asked to look at pictures of actions presented on the screen and decide if the auditory stimulus accompanying each picture corresponded to the picture or not by providing an oral yes/no response.

Auditory stimuli consisted of the same 27 verbs recorded in isolation in their infinitive form (without *to* in English). These recordings were used to create both congruent and incongruent trials (i.e., trials in which the verb matched or mismatched the depicted actions). The auditory verb on incongruent trials was always semantically unrelated and started with a different phoneme to the depicted verb.

During the task, the experimenter first showed a practice image and provided a correct response. Then, participants were asked to complete three more practice items in both congruent and incongruent conditions.

After prompting the participant to ask any clarification questions, the experimental part started. The total number of 54 items (27 congruent and 27 incongruent) was divided into two lists counterbalanced for verb type and condition. Each list was presented in a separate session in a semi-random item order (based on the same conditions as previous tasks) so that each participant heard all verbs paired with congruent and incongruent images, but no visual or auditory stimulus was repeated within one session.

Correct responses were "yes" to congruent and "no" to incongruent stimuli. If more than one response was provided, the final one was scored. The experimenter was instructed to repeat the audio recording upon participant's request to overcome problems resulting from occasional internet connection interferences that sometimes led to suboptimal sound transmission.

5. Sentence-picture verification task
In this task, participants followed the same procedure as in the verb-picture verification task and the same scoring procedure was used. The only difference were the presented auditory stimuli, which were now full sentences, either congruent or incongruent with the visual stimuli.

The auditory stimuli for this task consisted of 27 congruent and 27 incongruent sentences recorded for every language. Every sentence consisted of a subject, a verb from the final stimuli list and either an object for transitive sentences or a complemental phrase (i.e., adjectival phrase, prepositional phrase or a complement) for intransitive sentences. All the lexical items used as subjects, verbs and objects/complemental phrases were controlled for logarithmic frequency and all the lexical items and sentences were controlled for length in letters and syllables. On congruent trials, the verb in the auditorily presented sentence described the depicted action in the image. On incongruent trials, the verb was a different verb of the same type from the final stimuli list, which was semantically unrelated and started with a different phoneme to the depicted verb. The sentences presented in present perfect tense in Peninsular Spanish *(e.g., el chico ha corrido muy rápido / the guy has run very fast)* and its Basque equivalent (e.g., *emakumea airean erori da / the woman has fallen through the air*). For English stimuli, we used progressive present tense (e.g., *the girl is pouring the water*) and its equivalent for Latin-American Spanish (e.g., *el chico está corriendo muy rápido*).

6. Story-picture verification task

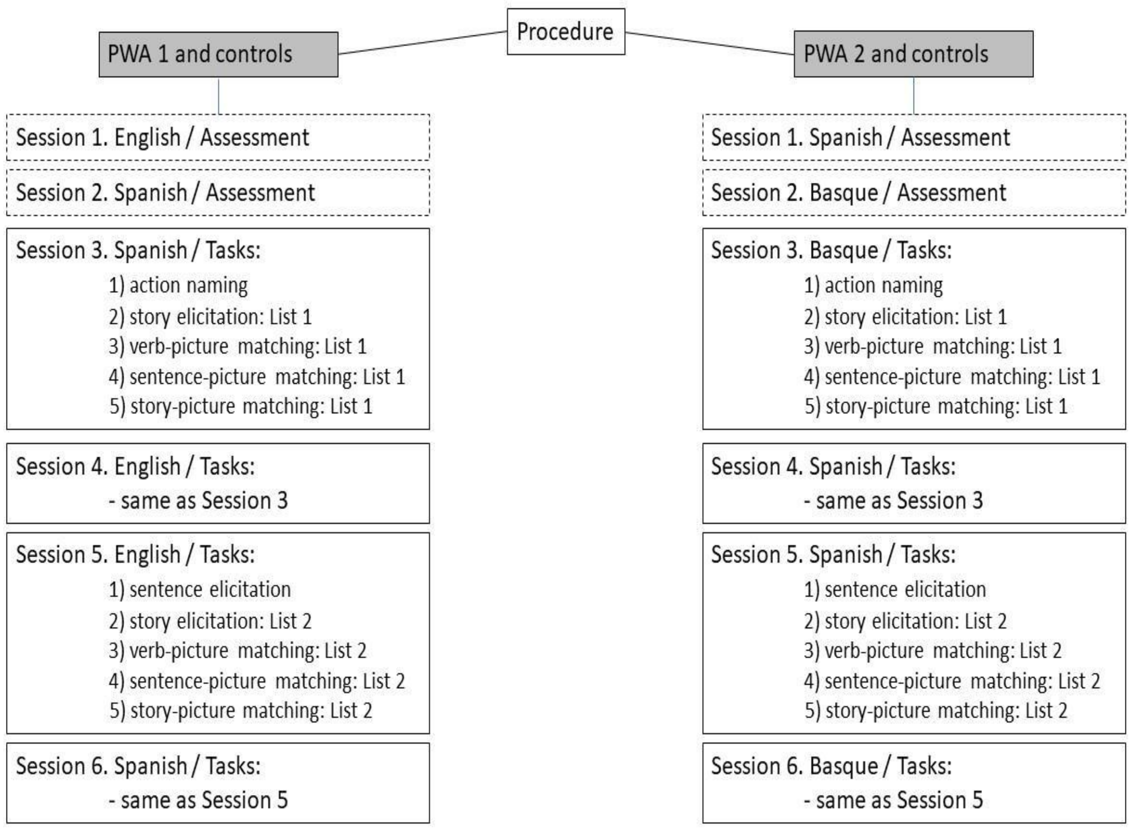
In this task, participants were asked to look at the four images depicting a short story (the same visual stimuli were also used in the story elicitation task), listen to a narrative and decide if the narrative fully corresponded to the visual stimuli or not by providing an oral yes/no response. Participants were allowed to give a *no* response at any point in the story when they heard an incongruence but they had to wait until the end (once they made sure there were no inaccuracies in the whole trial) to give a *yes* response indicating a congruent trial.

To create the auditory stimuli for this task, we recorded 30 short stories (15 congruent and 15 incongruent) that contained the verbs from the verb stimuli list. The incongruent trials were created by substituting one of the three target verbs in every story with another, semantically unrelated verb of the same type. The incongruent verbs always differed from the congruent ones in the first phoneme and they appeared in counterbalanced positions across stories (i.e., they occurred equally often across the four story segments throughout the experiment). All 27 verbs were used at least once and at most twice as a congruent verb and at most once as an incongruent verb across all stories. Additionally, all the adjectives, adverbs and nouns in the stories were controlled for logarithmic frequency and stories were matched in syllable and letter length.

The experimenter presented one practice story and provided a correct response. This was followed by one more practice story to which participants responded and then they were encouraged to ask any clarification questions. Once demonstrating that they have understood the task, the experimental part began. The 30 stories were split into two counterbalanced semi-random ordered lists (15 stories each) and every participant was shown only one list during each session to avoid presenting stimuli in both congruent and incongruent conditions within a session.

The scoring procedure was identical as for the verb-picture and sentence-picture verification task. Participants did not have to identify the segment where the error occurred, only to indicate that one did occur within the presented story.

Appendix C.7. Experimental design. The sessions, their languages and task order for each PWA and their controls.



Appendix C.8. Assessment

C.8a. Scores for PWA1 and controls in Spanish (= SP) and English (= EN); the tasks used in this assessment were adapted from *The Multilingual Naming Test* (= MiNT; Gollan et al., 2012), *The Verb and Sentence test* (= VAST; Bastiaanse et al., 2002), *An Object and Action Naming Battery* (= OANB; Druks & Masterson, 2000), *The Narrative Story Cards* (= NSC; Helm-Estabrooks & Nicholas, 2003) and *The Peabody Picture Vocabulary Test* (= PPVT; Dunn & Dunn, 1981); all stimuli in the adapted assessment were controlled for cognates across the tested language pair and for overlap with our experimental stimuli.

	PWA1				C1				C2				C3			
	SP		EN		SP		EN		SP		EN		SP		EN	
Tasks	score	%	score	%	score	%	score	%	score	%	score	%	score	%	score	%
Object naming (MiNT)	8/10	80	10/10	100	10/10	100	10/10	100	10/10	100	10/10	100	10/10	100	10/10	100
Action naming (VAST)	8/10	80	8/10	80	10/10	100	10/10	100	10/10	100	10/10	100	9/10	90	9/10	90
Sentence completion (OANB)	7/10	70	9/10	90	10/10	100	10/10	100	10/10	100	10/10	100	10/10	100	10/10	100
Picture sequence description (NSC)	4/8	50	5/8	62.5	6/8	85.7	7/8	87.5	5/8	62.5	6/8	85.7	7/8	87.5	6/8	85.7
Object comprehension (PPVT)	7/8	87.5	6/8	75	8/8	100	8/8	100	8/8	100	8/8	100	8/8	100	8/8	100
Verb comprehension (VAST)	6/7	86	6/7	86	7/7	100	7/7	100	7/7	100	7/7	100	6/8	85.7	7/7	100
Sentence comprehension (VAST)	2/8	25	4/8	50	8/8	100	7/8	87.5	8/8	100	8/8	100	6/8	75	8/8	100
actives	1/4	25	1/4	25	4/4	100	3/4	75	4/4	100	4/4	100	3/4	75	4/4	100
relatives	1/4	25	3/4	75	4/4	100	4/4	100	4/4	100	4/4	100	3/4	75	4/4	100
Total	42/61	**68.9**	48/61	**78.7**	59/61	**96.7**	60/61	**98.4**	59/61	**96.7**	60/61	**98.4**	56/61	**91.80**	58/61	**95.1**

C.8b. Scores for PWA2 and controls in Spanish (= SP) and Basque (= BQ); the tasks used in the assessment were adapted from *Battery for evaluation of aphasia* (=BETA; Cuetos Vega & González-Nosti, 2009), from Brookshire & Nicholas (1993) and from *the Northwestern Assessment of Verbs and Sentences* (=NAVS; Thompson, 2011); all stimuli in the adapted assessment were controlled for cognates across the tested language pair and for overlap with our experimental stimuli.

	PWA2				C1				C2				C3			
	SP		BQ		SP		BQ		SP		BQ		SP		BQ	
Tasks	score	%	score	%	score	%	score	%	score	%	score	%	score	%	score	%
Object naming (BETA)	7/9	77.8	4/10	40	10/10	100	10/10	100	9/10	90	9/10	90	10/10	100	9/10	90
Action naming (BETA)	4/9	44.4	4/9	44.4	9/9	100	9/9	100	9/9	100	8/9	88.9	9/9	100	8/9	88.9
Picture description (Brookshire & Nicholas, 1993)	10/16	62.5	9/16	56.2	11/16	68.8	13/16	81.3	15/16	93.8	16/16	100	15/16	93.8	16/16	100
Object comprehension (BETA)	15/15	100	16/16	100	16/16	100	16/16	100	16/16	100	16/16	100	16/16	100	16/16	100
Verb comprehension (NAVS)	10/10	100	10/10	100	10/10	100	10/10	100	10/10	100	10/10	100	10/10	100	10/10	100
Sentence comprehension (BETA)	14/20	70	12/20	60	18/20	90	20/20	100	17/20	85	18/20	90	17/20	85	18/20	90
- relatives	4/4	100	4/4	100	4 /4	100	4/4	100	4 /4	100	4/4	100	3/4	75	3/4	75
- passives	3/4	75	1/4	25	4 /4	100	4/4	100	4 /4	100	3/4	75	4/4	100	4 /4	100
- subject focused	4/4	100	3/4	85	3 /4	75	4/4	100	3 /4	75	4/4	100	4/4	100	4 /4	100
- object focused	1/4	25	1/4	25	4 /4	100	4/4	100	3 /4	75	3/4	75	3/4	75	4 /4	100
- progressives	2/4	50	3/4	85	3 /4	75	4/4	100	3 /4	75	4/4	100	3/4	75	3 /4	75
Total	60/79	**80**	55/81	**64.7**	74/81	**91.4**	78/81	**96.3**	76/81	**93.8**	77/81	**95.1**	77/81	**95.1**	77/81	**95.1**

Appendix C.9. Proportions of verbs: Story elicitation task. Counts and percent proportions of verb types (UNERG: unergatives; UNACC: unaccusatives, TRANS: transitives; others: auxiliaries and other verb types) produced by PWA1, PWA2 and controls (taken from the control group means) during the story elicitation task.

	UNERG	**UNACC**	**TRANS**	**others**	**total**	**UNERG**	**UNACC**	**TRANS**	**others**	**total**
	SPANISH					**ENGLISH**				
PWA1	11	8	24	26		15		31	17	
(%)	(15.94)	(11.59)	(34.78)	(37.68)	**69**	(21.13)	8 (11.27)	(43.66)	(23.94)	**71**
Controls	25	15	44	27		29		36	35	
(%)	(22.29)	(13.25)	(40.26)	(24.40)	**111**	(26.75)	9 (8.51)	(32.52)	(32.22)	**110**
	SPANISH					**BASQUE**				
PWA2	13	11	25	35		18	10	24	33	
(%)	(15.48)	(13.10)	(29.76)	(41.67)	**84**	(21.18)	(11.76)	(28.2)	(38.8)	**85**
Controls	25	16	31	26		10	33	25	9	
(%)	(25.17)	(16.67)	(31.97)	(26.19)	**98**	(13.36)	(42.24)	(32.76)	(11.64)	**77**

Appendix C.10. Transcribed responses. Oral responses from production tasks for PWA1 and PWA2; the action naming and sentence elicitation task responses are listed in the randomized order of trials as they appeared on the screen, while story elicitation task responses are ordered by story verb types (not how the trials were actually shown during the experiment).

PWA1: SPANISH | Action naming task

trial	target verbs	type	response	correct
1	aplaudir (clap)	UNERG	*aplaudir*	1
2	aspirar (vacuum)	TRANS	*limpiar*	1
3	llorar (cry)	UNERG	*llorar*	1
4	tomar/beber (drink)	TRANS	*beber*	1
5	tropezar[se] (trip)	UNACC	*tropezar*	1
6	chocar[se] (crash)	UNACC	*choque*	0
7	cantar (sing)	TRANS	*cantar*	1
8	hervir (boil)	UNACC	*cocinar*	1
9	correr (run)	UNERG	*corriendo*	1
10	secar(se) (blow-dry)	TRANS	*blo… bloia… blo… aj, no puedo*	0
11	nadar (swim)	UNERG	*nadar*	1
12	ladrar (bark)	UNERG	*ladrar*	1
13	barrer (sweep)	TRANS	*escoba, sacando el polvo*	1
14	escalar (climb)	UNERG	*trepando*	1
15	despegar (take off)	UNACC	*avión, se va, se va por el aeropuerto*	1
16	caer[se] (fall)	UNACC	*se cayó o nadando*	1
17	pintar (paint)	TRANS	*pintan*	1
18	florecer (bloom)	UNACC	*una flor abriendo*	1
19	colgar/tender (hang)	TRANS	*secando*	1
20	quemar[se] (burn)	UNACC	*un fuego, quemandose*	1
21	saltar (jump)	UNERG	*brincando*	1
22	morder (bite)	TRANS	*comiendo*	1
23	resbalar[se] (slip)	UNACC	*resbalar*	1
24	sonar (ring)	UNACC	*telefono, ring ring, sonando*	1
25	cocinar (cook)	TRANS	*cocinar*	1
26	volar (fly)	UNERG	*superman, volando*	1
27	reir[se] (laugh)	UNERG	*llorando*	0
TOTAL				24/27

PWA1: SPANISH | Sentence elicitation task

trial	target verbs	type	response	correct
1	resbalar[se] (slip)	UNACC	*el hombre resbaló se resbaló*	1
2	aplaudir (clap)	UNERG	*el hombre está aplaudiendo*	1
3	hervir (boil)	UNACC	*hmm la olla está hirviendo*	1
4	cantar (sing)	TRANS	*la mujer está cantando*	1
5	chocar[se] (crash)	UNACC	*hubo había dos caros colision como se dice, dos caros chocaron*	1
6	despegar (take off)	UNACC	*el avión se fue*	1
7	nadar (swim)	UNERG	*el hombre está nadando*	1
8	colgar/tender (hang)	TRANS	*el hombre está secando la ropa*	1
9	saltar (jump)	UNERG	*esta la la mu la muchacha está brincando brincando*	1
10	tomar/beber (beber)	TRANS	*ella está bebiendo hugo o agua*	1
11	sonar (ring)	UNACC	*el teléfono está sonando*	1
12	quemar[se] (burn)	UNACC	*la casa se quemó*	1
13	aspirer (vacuum)	TRANS	*el hombre está limpiando la alfombra*	1
14	barrer (sweep)	TRANS	*el hombre está barriendo*	1
15	escalar (climb)	UNERG	*el hombre está subiendo la loma*	1
16	volar (fly)	UNERG	*el esta flying, el está en el aire*	1
17	pintar (paint)	TRANS	*ella está pintando la casa*	1
18	correr (run)	UNERG	*el está corriendo*	1
19	morder (bite)	TRANS	*el gato está comiendose un un un paňo*	1
20	caer[se] (fall)	UNACC	*ella se cayó*	1
21	cocinar (cook)	TRANS	*el cocinero esta cocinando*	1
22	llorar (cry)	UNERG	*el hombre está llorando*	1
23	florecer (bloom)	UNACC	*la flor está abriendo*	1
24	tropezar[se] (trip)	UNACC	*el hombre tropezó con la caja*	1
25	secar[se] (dry-blow)	TRANS	*ella se está bloyando, usando el blower, secándose el pelo*	1
26	ladrar (bark)	UNERG	*el perro está ladrando*	1
27	reír[se] (laugh)	UNERG	*ella se está riendo*	1
TOTAL				27/27

PWA1: SPANISH | Story elicitation task

story	target verbs	type	response	correct
1	llorar (cry)	UNERG	*ella está llorando* *ve a una mariposa* *se le acerca…la nene se le acerca la mariposa*	1
	volar (fly)			1
	reír (laugh)			NA/0
2	volar (fly)	UNERG	*él está cansado…le empezó a ladrar a un pájaro,* *el perro le estaba ladrando también al pájaro* *y después se fue corriendo detrás del del pájaro*	1
	ladrar (bark)			1
	correr (run)			1
3	llorar (cry	UNERG	*hay un niño en en…. en un árbol, está llorando,* *la mamá está diciendo pidiendo ayuda yo creo,* *ahí están ya bomberos los bomberos llegaron, llegron y la mamá estaba aplaudiendo porque salvaron al niño*	1
	escalar (climb)			1
	aplaudir (clap)			1
4	nadar (swim)	UNERG	*hay dos un niño y una nena nadando,* *el ni.. la niña se brin.. brincó la tabla,* *they both splashes, la los dos se se splash y él niño tenía fri.., no el niño estaba enfogonado porque la niña lo splash himself, no me sale la palabra hoy.*	1
	saltar (jump)			1
	reír (laugh)			1
5	nadar (swim)	UNERG	*la nena está.. hay una nena ehm y hay unos pecesitos, a.. el salvavidas está mirando, ehm el agua se subió y el trató de de ehm de buscarla ..ella él se se tiró al agua y salvó a la niña*	1
	correr (run)			1
	saltar (jump)			1
6	hervir (boil)	UNACC	*ella está cocinando, ehm están haciendo papa, boiling bol pottato, y sonó el teléfono y* *y se se.. se.. splash.. se splash on the stove,* *no me sale la palabra en español en inglés en español, splash y viendo la la olla se salió el fuego, that's all I could say …*	0
	sonar (ring)			1
	quemar (burn)			1
7	caer (fall)	UNACC	*hay una nena, está comiéndose una.. un guineo,* *tiro la la el guineo en la calle,* *el hombre se resbaló y hubo hubo se cayó y* *y se dio eh con el caro*	1
	resbalar(slip)			1
	chocar (crash)			1
8	florecer (bloom)	UNACC	*muchos árboles, tiene un [??]eleta cala..calentándose las manos,* *la muchacha se le voló la la gorra* *y en el fuego se le quemó la gorra, el sombrero*	Na/0
	tropezar (trip)			1
	quemar (burn)			1
9	chocar (crash)	UNACC	*hubo un choque en el aeropuerto,* *lo estaban tratando de llamar en el en el aeropuerto, estaba tarde, parece,* *y el avión se fue, se fue el avión hubo un choque en el aeropuerto*	1
	sonar (ring)			1
	despegar (take off)			1
10	florecer (bloom)	UNACC	*hay muchas flores, ehhm..la abeja quiere beber miel, se rompió el.. el.. la.. el.. la..* *la se rompió el donde está la la miel y se cayó en el pisó*	1
	caer (fall)			1
	despegar (take off)			Na/0

11	pintar (paint)	TRANS	*el hombre está pintando hay mucha pintura en el piso, la la esposa está tratando de limpiarlo y lo limpió con con le pusó pasó un vacuum a la pintura*	1
	barrer (sweep)			1
	aspirer (vacuum)			1
12	cocinar (cook)	TRANS	*un cocinero está haciendo algo en la cocina, él está.. ehm stirring,. hay no me sale la palabra, el está stirring eh y el gato está mirando, el el gato tiene hambre, está tiene mucha hambre y el y el señor le estaba dando comida, no me salen la palabra hoy*	0
	beber (drink)			1
	morder (bite)			1
13	tender (hang)	TRANS	*ella está secando la ropa esta cantando porque salió tiene sol al fuera después rela..hubo un relámpago y el trató de sacarse con blower*	1
	cantar (sing)			1
	secar (blow-dry)			1
14	pintar (paint)	TRANS	*ella está pintando la casa; la brocha se cayó el el el perro, el perro le mordió, se cayó la brocha le le perro le mordió muy muy duro a la a la a la doňa y la pintura se cayó en tuvo que esté tuvo que barrer la pintura, la brocha*	1
	morder (bite)			1
	barrer (sweep)			1
15	cocinar (cook)	TRANS	*está cocinando, ella está cocinando, está cantando también, esta mapiando y él tiene hambre*	1
	cantar (sing)			1
	secar (blow-dry)			0
TOTAL				39/45

PWA1: ENGLISH | Action naming task

trial	target verbs	type	response	correct
1	snore	UNERG	*snoring*	1
2	sink	UNACC	*sinking*	1
3	push	TRANS	*push*	1
4	throw	TRANS	*I don't' know that one*	0
5	freeze	UNACC	*temperature, low temperature*	0
6	crawl	UNERG	*reaching*	1
7	burn	UNACC	*fire, burning*	1
8	mail	TRANS	*mail, dropping, mail*	1
9	rot	UNACC	*spoil*	0
10	stir	TRANS	*stirring*	1
11	wave	UNERG	*stop*	1
12	run	UNERG	*jugging*	1
13	pour	TRANS	*pouring*	1
14	spin	UNACC	*turning*	1
15	kneel	UNERG	*kneeling*	1
16	kick	TRANS	*kicking*	1
17	melt	UNACC	*dripping, not dripping*	0
18	boil	UNACC	*boiling*	1
19	vacuum	TRANS	*vacuum*	1
20	shiver	UNERG	*cold, sweating, shivering (lexical clue)*	0
21	sweat	UNERG	*sweating*	1
22	fall	UNACC	*dropping*	0
23	water	TRANS	*flower, gardening*	1
24	wink	UNERG	*winking*	1
25	laugh	UNERG	*laughing*	1
26	slap	TRANS	*smacking*	1
27	hang	UNACC	*drying cloths, drying*	1
TOTAL				21/27

PWA1: ENGLISH | Sentence elicitation task

trial	target verbs	type	response	correct
1	melt	UNACC	*the snowman is shivering*	0
2	crawl	UNERG	*The baby is.. the baby is.. reaching reaching*	1
3	kick	TRANS	*the man is kicking the box*	1
4	run	UNERG	*the man is running*	1
5	pour	TRANS	*the lad ...woman is pouring water*	1
6	laugh	UNERG	*the lady ...the woman is laughing*	1
7	hang	UNACC	*the clothes the the clothes is drying*	1
8	fall	UNACC	*the the girl fall down*	1
9	water	TRANS	*the man is flowering the flow.. the the man is putting down some water*	0
10	wave	UNERG	*the man is saying bye or stop*	1
11	burn	UNACC	*the house got burned*	1
12	vacuum	TRANS	*the man is cleaning the rug*	1
13	wink	UNERG	*the man is winking*	1
14	shiver	UNERG	*the man is cold*	1
15	slap	TRANS	*the lady smacked at the man*	1
16	boil	UNACC	*the stove is bowling water*	0
17	sweat	UNERG	*the man is sweating*	1
18	push	TRANS	*the man is pushing the car*	1
19	freeze	UNACC	*the temperature is going down*	1
20	stir	TRANS	*the lady is stirring the bowl*	1
21	rot	UNACC	*the apple is is is rotting*	1
22	kneel	UNERG	*the man is kneeling down*	1
23	throw	TRANS	*there we go the man is ..throwing something I forgot the name of it*	1
24	snore	UNERG	*the man is sleeping is snoring*	1
25	mail	TRANS	*the man is putting the man is the man is the man is something in a mailbox a letter in a mail box the man is sending a letter in the mailbox*	1
26	spin	UNACC	*I forgot that one something turning with a cord, spinning, I know its turning*	1
27	sink	UNACC	*the boat iks tinking*	1
TOTAL				24/27

PWA1: ENGLISH | Story elicitation task

story	target verbs	type	response	correct
1	kneel	UNERG	*the the man and the la.. the man and the lady was in the park, she.. the I don't want to say the old lady, the lady he took a ring I guess she was proposing to the to the lady and she walk out in..*	1
	sweat			1
	run			1
2	wave	UNERG	*the man the lad..the boy was walking ehm the girl and the boy went to to the wa.. I guess they were gonna go to school; they were walking, she he she he had a bag a dog in a bag and she was happy because the dog licked him*	1
	wink			1
	laugh			1
3	snore	UNERG	*she was he was snoring so much that she could not take it, she got mad she walked out the door the the bedroom, she was so mad and angry, and she tried to crawl back to the bed*	1
	shiver			1
	crawl			1
4	kneel	UNERG	*he is thinking, he is thinking, ehm he is waving, the the the man is waving at the boy, ehm, he is climbing, he he is go-going down the the fence and he is getting a carrot*	1
	wave			1
	crawl			0
5	shivering	UNERG	*its winter.. the girl, she has winter clothes, she is cold.. she sees the boy running and and she and the boy is hot.. dio mio..*	1
	running			1
	sweating			1
6	spin	UNACC	*there is a carousel with the boy and the and the mother, there is a tornado going around the boy is trying to get in but he is left off the horsey and the mother got mad*	1
	hang			1
	fall			0
7	freeze	UNACC	*its winter, they putting a hat on a snowman the boy and a girl, it was it was it was summer and the.. the boy and the girl the snowman melted*	1
	melt			1
	fall			Na/0
8	boil	UNACC	*he.. he.. was boiling water with food, she I guess she was trying to do marshmallow, the marshmallow dropped, not dropped but dripped and and the boy was sad that the boy was sad because he he the marshmallow melted*	1
	melt			1
	burn			Na/0
9	boil	UNACC	*she was boiling, the lady was boiling water, she was trying to put potato but the potato got rotten and she cooked them anyway*	1
	rot			1
	burn			1
10	freeze	UNACC	*its winter, ehm…ehm, the boat there is a boat there and they sinking, the two mens are sinking and one of them fell off the boat*	1
	sink			1
	hang			0
11	throw	TRANS	*the girl is playing by herself, there is a boy that's, that's there is a boy hitting her in the arm, in the in the back,*	1
	push			1

	slap		*the boy was laughing, because she missed the ball and the boy smacked him on the face*	1
12	water	TRANS	*she.. he is flowering the roses*	0
	mail		*the man sees the la.. girl putting mail putting mail on in the mailbox, the the girl the the letter*	1
	pour		*flew out of her hand and the boy the man em.. with the.. water the letter? ok*	1
13	vacuum	TRANS	*the boy is cleaning the rug*	1
	kick		*one of the toys got stuck to the machine the boy the boy try to fix to kick it*	1
	slap		*and the mother smack him in the face*	1
14	stir	TRANS	*they were cooking, he was,*	1
	pour		*I guess they were doing ehm they were I guess they were trying to do pancakes she poured it down on the on the on the stove*	1
	throw		*and she flipped it on the, on the I am so bad today on the frying pan I am like oh my god and she she would ehm she try to put the pancake on the frying pan*	1
15	push	TRANS	*she she she has a wagon,*	1
	water		*she put water in it*	0
	kick		*she flower, she put water on on the flower and then she kicked it off*	1
TOTAL				38/45

PWA2: SPANISH | Action naming task

trial	target verbs	type	response	correct
1	cantar (sing)	UNERG	*cantar*	1
2	hervir (boil)	UNACC	*hervir*	1
3	saltar (jump)	TRANS	*saltar*	1
4	quemarse (burn)	TRANS	*quemar*	1
5	morder (bite)	UNACC	-	0
6	despegar (take off)	UNERG	*volar*	1
7	tender (hang)	UNACC	*zintzilikatu*	0
8	correr (run)	TRANS	*correr*	1
9	nadar (swim)	UNACC	*nadar*	1
10	resbalar (slip)	TRANS	*caer*	1
11	barrer (sweep)	UNERG	*limpiar*	1
12	reír (laugh)	UNERG	*reir*	1
13	volar (fly)	TRANS	*volar*	1
14	florecer (bloom)	UNACC	*crecer*	1
15	aspirar (vacuum)	UNERG	*limpiar*	1
16	sonar (ring)	TRANS	-	0
17	secar (blow-dry)	UNACC	*secar*	1
18	tropezar (trip)	UNACC	*caer*	1
19	cocinar (cook)	TRANS	*cocinar*	1
20	caer (fall)	UNERG	*caer*	1
21	ladrar (bark)	UNERG	*gritar*	0
22	chocar (crash)	UNACC	*chocar*	1
23	pintar (paint)	TRANS	*pintar*	1
24	llorar (cry)	UNERG	*llorar*	1
25	escalar (climb)	UNERG	*escalar*	1
26	beber (drink)	TRANS	*beber*	1
27	aplaudir (clap)	UNACC	*aplauso*	0
TOTAL				22/27

PWA2: SPANISH | Sentence elicitation task

trial	target verbs	type	response	correct
1	resbalar (slip)	UNACC	*el hombre se está cayendo por por el plátano*	1
2	pintar (paint)	UNERG	*la mujer está pintando la pared*	1
3	volar (fly)	TRANS	*el hombre está volando*	1
4	nadar (swim)	UNERG	*el hombre está nadando*	1
5	beber (drink)	TRANS	*la mujer está bebiendo agua*	1
6	caer (fall)	UNERG	*la mujer se está cayendo*	1
7	aplaudir (clap)	UNACC	*el hombre está aplaudendo*	1
8	saltar (jump)	UNACC	*la niña está saltando*	1
9	cocinar (cook)	TRANS	*el hombre está cocinando la comida*	1
10	florecer (bloom)	UNERG	*la flor está flo-re-ciendo*	1
11	reír (laugh)	UNACC	*la mujer se está reiendo*	1
12	cantar (sing)	TRANS	*la mujer está cantando*	1
13	hervir (boil)	UNERG	*el agua se está hiervir no se*	0
14	despegar (take off)	UNERG	*el avión se está volando*	1
15	ladrar (bark)	TRANS	*el perro está gritando*	0
16	morder (bite)	UNACC	*el gato esta no se pasa*	0
17	tropezar (trip)	UNERG	*el hombre se está cayendo*	1
18	llorar (cry)	TRANS	*el hombre está llorando*	1
19	barrer (sweep)	UNACC	*el hombre se está barriendo*	1
20	chocar (crash)	TRANS	*el coche esta chocando contra otro coche*	1
21	aspirar (vacuum)	UNACC	*el hombre está eee limpiando el suelo*	1
22	correr (run)	UNERG	*el hombre está corriendo*	1
23	escalar (climb)	TRANS	*el hombre está escalando*	1
24	tender (hang)	UNERG	*el hombre está colgando la ropa*	1
25	secar (blow-dry)	TRANS	*la mujer se está secando la el pelo*	1
26	sonar (ring)	UNACC	*el teléfono está sonando*	1
27	quemarse (burn)	UNACC	*la casa se está quemando*	1
TOTAL				24/27

PWA2: SPANISH | Story elicitation task

story	target verbs	type	response	correct
1	llorar (cry)	UNERG	*hay una niña sentada en el en el en el banco llorando; ve una mariposa y va hacia su brazo y al final por el por la mariposa está contenta y al final se va la pared la mariposa*	1
	volar (fly)			1
	reír (laugh)			1
2	volar (fly)	UNERG	*hay un perro mediodormido y ve una un pája pájaro ee volando y grita el perro y el pájaro se enfada no se no se hey le sorprende y al final el ee perro está corriendo para coger el pájaro*	1
	ladrar (bark)			0
	correr (run)			1
3	llorar (cry)	UNERG	*hay un niño llorando encima del árbol y su madre está preocupada el hombre ha subido el agua o sea hostras el árbol para ayudar y la madre está contenta*	1
	escalar (climb)			1
	aplaudir (clap)			1
4	nadar (swim)	UNERG	*ay dos niños contentos en la piscina nadando la niña ee ha saltado al agua el le ha sa sal mierda salficado no se algo así y entonces el niño se ha enfadado porque porque se ha no me sale el hombre o sea la palabra así que pasa*	1
	saltar (jump)			1
	reír (laugh)			1
5	nadar (swim)	UNERG	*hay una niña ee nadando en en el mar y hay un hombre en la playa y luego ha visto a la niña que que que tiene un problema por la por la ola y al final ha ido el hombre a la niña para ayudar*	1
	correr (run)			1
	saltar (jump)			1
6	hervir (boil)	UNACC	*hay una mujer cocinando y el agua está hierviendo y bueno el teléfono ha sonado y habrá cogido el teléfono y al final el agua eee se está quemando?*	1
	sonar (ring)			1
	quemarse (burn)			1
7	caer (fall)	UNACC	*hay una niña en la calle con un plátano comiendo ha tirado la cascara y el hombre se ha se ha se ha caído porque ee por el plátano y al final eee ha caído al a la carretera y no pasa*	1
	resbalar (slip)			1
	chocar (crash)			0
8	florecer (bloom)	UNACC	*hay un un camino al lado de los árboles y hay un un chico al lado del fuego y al calor hay una chica que se está cayendo porque el árbol se ha caído y su sombrero ee.. esta vola.. volando y al final ee ha llegado al fuego y se está quemando y el hombre bueno el chico él lo está sorpre.. sorprendido*	1
	tropezar (trip)			1
	quemarse (burn)			1

9	chocar (crash)	UNACC	*ee hay dos coches y le ha chocado a uno y están al lado del aeropuerto han dicho que que nada vuela el avión y está el.. el hombre mirando la.. la.. el reloj y mira la hora y ve que ya no llega al avión y esta enfadado o triste*	1
	sonar (ring)			1
	despegar (take off)			1
10	volar (fly)	UNACC	*hay un perro mediodormido y ve una un pája pájaro ee volando y grita el perro y el pájaro se enfada no se no se hey le sorprende y al final el ee perro esta corriendo para coger el pájaro*	1
	ladrar (bark)			1
	correr (run)			1
11	pintar (paint)	TRANS	*hay un hombre pintando la pared y se ha caído la pintura en el suelo y una mujer está ee está barriendo el suelo*	1
	barrer (sweep)			1
	aspirar (vacuum)			Na/0
12	cocinar (cook)	TRANS	*el hombre está en la cocina y está haciendo ee.. la comida y hay un gato detrás de él el gato tiene hambre y está bebiendo agua y al final le ha dado el hombre un hueso al gato*	1
	beber (drink)			1
	morder (bite)			1
13	tender (hang)	TRANS	*hay una mujer colgando la ropa y está cantando porque hace buen tiempo al final llueve y la ropa esta mojada y luego el.. el.. hombre coge el secador y lo seca*	1
	cantar (sing)			1
	secar (blow-dry)			1
14	pintar (paint)	TRANS	*hay un ee hay una mujer pintando la pared con el sobre un ee escalera el perro le.. no se.. el verbo. O sea.. comer no come. y entonces se cae el pincel, la mujer esta enfadada y se ha pintado el suelo también y está limpiando todo*	1
	morder (bite)			0
	barrer (sweep)			1
15	cocinar (cook)	TRANS	*hay una mujer cortando la patata y está cantando y detrás allí agua en el suelo y al final lo está limpiando y el hombre tiene hambre y quiere comer*	1
	cantar (sing)			1
	secar (blow-dry)			1
TOTAL				41/45

PWA2: BASQUE | Action naming task

trial	target verbs	type	response	correct
1	arrantzatu (fish)	UNERG	*pescar, arrantzatu*	1
2	tiratu/ireki (pull)	UNACC	*ireki*	1
3	margotu (paint)	TRANS	*marraztu*	0
4	belaunikatu (kneel)	TRANS	-	0
5	bultzatu (push)	UNACC	*bultza*	1
6	dantzatu (dance)	UNERG	*dantzatu*	1
7	biratu (spin)	UNACC	*jiratu*	1
8	jaurti (throw)	TRANS	*bota*	1
9	patinatu (skate)	UNACC	*patinatu*	1
10	bidaiatu (travel)	TRANS	*bidaiatu*	1
11	moztu (cut)	UNERG	*moztu*	1
12	hondoratu (sink)	UNERG	*hundir*	0
13	amestu (dream)	TRANS	*amets egin*	1
14	josi (sew)	UNACC	*jostu*	1
15	esnatu (wake up)	UNERG	*esnatu*	1
16	izoztu (freeze)	TRANS	*hotza*	0
17	ureztatu (water)	UNACC	*ura bota*	1
18	erori (fall)	UNACC	*erori*	1
19	urtu (melt)	TRANS	-	0
20	eskalatu (climb)	UNERG	*eskalatu*	1
21	konpondu (repair)	UNERG	-	0
22	nabigatu (sail)	UNACC	-	0
23	haserretu (get angry)	TRANS	*haserretu*	1
24	eskiatu (ski)	UNERG	*eskiatu*	1
25	plantxatu (iron)	UNERG	*plantxatu*	1
26	pentsatu (think)	TRANS	*pentsatu*	1
27	irristatu (slip)	UNACC	*erori*	1
TOTAL				20/27

PWA2: BASQUE | Sentence elicitation task

trial	target verbs	type	response	correct
1	margotu (pain)	UNACC	*ema emakumea marrazten ari da pareta*	0
2	plantxatu (iron)	UNERG	*e.. gizona plantxatzen ari da arropa*	1
3	urtu (melt)	TRANS	*panpina urtzen ari da*	1
4	eskiatu (ski)	UNERG	*ee.. gizona es.. eskiatzen ari da*	1
5	moztu (cut)	TRANS	*umea mozten ari da ee orria*	1
6	pentsatu (think)	UNERG	*gizona pentsatzen ari da*	1
7	tiratu (pull)	UNACC	*gizona ee iriki... irikitzen ari da atea*	1
8	amestu (dream)	UNACC	*umea pentsatzen…ez bueno ez... eee umea amets egiten ari da*	1
9	irristatu (slip)	TRANS	*gizona irristratzen ee ari da*	1
10	izoztu (freeze)	UNERG	*hotza egiten du*	1
11	konpondu (repair)	UNACC	*gizona eee autoa*	0
12	esnatu (wake)	TRANS	*gizona esnatzen ari da ohean*	1
13	jaurti (throw)	UNERG	*ee.. umea botatzen ari da gauza hori*	1
14	arrantzatu (fish)	UNERG	*ez dakit aditza*	0
15	belaunikatu (kneel)	TRANS	*gizona belauna belau.. belaunatzen ari da*	1
16	ureztatu (water)	UNACC	*gizona rega rega regatzen ari da*	0
17	nabigatu (sail)	UNERG	*gizona neba neba nebagatzen ari da*	1
18	haserretu (get angry)	TRANS	*emakumea haserre dago*	1
19	patinatu (skate)	UNACC	*gizona patinatzen ari da*	1
20	bultzatu (push)	TRANS	*gizona eee tiratzen ari da kotxea*	0
21	erori (fall)	UNACC	*emakumea erortzen ari da*	1
22	dantzatu (dance)	UNERG	*emakumea dantzatzen ari da*	1
23	bidaiatu (travel)	TRANS	*gizona bidaiatzen ari da*	1
24	josi (sew)	UNERG	*emakumea josten ari da makina batekin arropa*	1
25	eskalatu (climb)	TRANS	*gizona eskalatzen ari da*	1
26	biratu (spin)	UNACC	*…jiratzen ari da..*	0
27	hondoratu (sink)	UNACC	*itsasontzia ez dakit aditza*	0
TOTAL				20/27

PWA2: BASQUE | Story elicitation task

story	target verbs	type	response	correct
1	nabigatu (sail)	UNERG	*ume bat dago velan, eee… itsasoan*	1
	arrantzatu (fish)		*eta gizon bat arrantzatzen* *eta gizonak… eeee.. nahi du arrai bat, edo*	1
	amestu (dream)		*pentsatzen ari da… eee… arraina nahi dula, arrantzatzen dagolako* *eta.. azkenean, eee… eee... sokan dago umea… eee… belakin itsasoan eta… eta… gizona haserre dago*	1
2	bidaiatu (travel)	UNERG	*pareja bat… eee... bidatzen.. bidaiatzen ari da kotxez, eta inguruan… eee… mendiak daude...*	1
	eskiatu (ski)		*eee... elurrakin* *eskiatzen ari dira*	1
	patinatu (skate)		*eta mutila, bueno, gizona, eee...nekatuta dago, edo ez zaio gustatzen* *eta azkenean, eeee… pareja… eeee… eskira… eskiatu ordez... ee.. patinatzen ari dira*	1
3	amestu (dream)	UNERG	*ume bat dago klasean, bueno, mahaian, eta*	1
	bidaiatu (travel)		*amets egin du*	1
	eskalatu (cimb)		*ametsan eee… juten ari da mendira* *eta… eee… igo du mendia oso azkar* *eta azkenean iritsi da goraino*	1
4	patinatu (skate)	UNERG	*eee… laku batean daude bi ume*	1
	pentsatu (think)		*eta lakua izoztuta dago, beraz patinatzen ari dira* *baina… eee… zulo bat dago lakuan eta… eee… arrain bat dago uran*	1
	arrantzatu (fish)		*beraz… eee… umeak arrantzatu du, bueno saiatzen ari da arrantzatzen arropa, osea arrai… arraina*	1
5	dantzatu (dance)	UNERG	*emakume batek ari da dantzatzen* *eta katu batek... eee… salto egin du lehio*	1
	eskalatu (climb)		*ondoan* *katua… katuak… eee… gosea dauka, eta ikusi*	1
	pentsatu (think)		*du emakumeak* *eta azkenean eman dio…eee… janaria katuari*	1
6	urtu (melt)	UNACC	*umea… umeak dauka.. eee.. helatu bat eta pozik*	1
	irristatu (slip)		*dago helatua urtzen ari da, eta, bera, eee… lurrean... eee… dago likidoa, elu… eee… elau… ela… eee…ela…. Eee... likidoa*	1
	hasseretu (get angry)		*eta beraz beste ume bat etorri da eta irristratu da eta haserre dago… eee... umea*	1
7	belaunikatu (kneel)	UNACC	*umea jolasten ari da… eee… jo…. mmm.. jolas... joku batekin… mmm… eee… eta bota du*	1
	biratu (spin)		*eta… eee… jokua jiratzen ari da…ee... ate.. eee... Ateraino*	1
	erori (fall)		*gizona… eee… eta azkenean gizona… eee… pasa da atetik*	1

			eta irristratu da	
8	izoztu (slip)	UNACC	*itsasontzi bat dago… itsasoan... gauean eta… gizon batek… eee… estru… no… estrujula... estrujula… o algo hasi, hartu du…eee... jakiteko non dagoen… iparra eta…eee... gaua denez, ez du ikusi… ize…beja? eta azkenean… eee… horrengatik… eee… ha hundido… eee… el barco*	1
	esnatu (wake up)			1
	hondoratu (sink)			1
9	urtu (melt)	UNACC	*elurrezko panpina.. eee.. dago kalean? eta... beroa egiten du. ordun… eee ez dakit aditza Araitz sais the word urtu; urtzen ari da eta… eeee.. mutil bat horrengatik erori da, ura dagolako eta haserretu da eta bukaeran ba elurra ordez dago ura*	1
	irristatu (slip)			1
	hasseretu (get angry)			1
10	belaunikatu (kneel)	UNACC	*eee.. neska.. bueno emakume bat dago ta... gizon bat gizona… eee…eee... ematen ari da eraztuna, neskari, ezkontzeko eta erori zaio a la alcantarilla*	1
	erori (fall)			1
	biratu (spin)			Na/0
11	jaurti (throw)	TRANS	*gizon bat… eee… dago txakur batekin bota dio pelota bat eta txakurra…eee…. korrika egin du eta horregatik amona erori da… eee… soka… soka gatik*	1
	tiratu (pull)			1
	bultzatu (push)			1
12	moztu (cut)	TRANS	*eee… emakumea mozten ari da tela eta amona josten ari da makinarekin.. eee… soieko bat egiteko baina soinekoa dago…. eee.... bueno azkenean amona plantxatzen ari da soinekoa, eta…eee…emakumea pozik dago.. hori da, bale*	1
	josi (sew)			1
	plantxatu (iron)			1
13	margotu (paint)	TRANS	*neska bat dago marrazten… eee… paretan eta pareta.. eee.. pareta... handia denez… eee.. ezin du marraztu goraino eta ordun… eee… gizon batek eman dio eskailera bat laguntzeko eta azkenean pos ahal du egin*	0
	bultzatu (push)			1
	konpondu (repair)			0
14	tiratu (pull)	TRANS	*eee.. landare bat dago… mmm... gaixo, a ver eske ez da gaixo, baino bueno behar du ura eta ordun neska bat… eee… neska batek hartuko du mangera… baina… baina… eee… gaizki dago ze… ura ateatzen da…. ateatzen da eta ordun, eeee… gizon batek hartu du…eeee... zeloa… ez eee.. ateratzeko ura eta azkenean… eeee…. neskak hartu mangera… eee.. ladea... landareari ura botatzeko*	1
	konpondu (repair)			1
	urezatu (water)			1
15	margotu (paint)	TRANS	*ume bat ari da… marrazten… eee… hegazkin bat*	1
	moztu (cut)			1

			eta bere amak… moztu du… eee…. orria, hartzeko bakarrik hegazkina	
	jaurti (throw)		*eee umeak hartu du egazkina eta bota.. bota du ahal duen hegan egin* *eta azkenean… eee… lehiotik… eee… bota du nahigabe, eta erres.. eee... haserre dago*	1
TOTAL				42/45

Appendix C.11. General cognitive functions. The administered tests included: *Coloured Progressive Matrices* (= CPM; Raven et al., 1995), visual forward span and visual backward span tasks from *Wechsler Memory Scale Revised* (= WMS-R; Elwood, 1991).

Test	Measured function	Results
		score / total
CPM	fluid intelligence	32 / 36
		recalled / total
WMS-R: Forward span	short-term memory	10 / 14
WMS-R: Backward span	working memory	9 / 12

Resumen amplio en castellano

Los verbos son una parte central del habla porque expresan quien hace qué a quien, información que se conoce como información de la estructura argumental. Investigaciones previas muestran que los costes asociados al procesamiento de la estructura argumental aumentan con el número de argumentos y/o como resultado del mapeo de argumentos no canónicos. Además, se ha reportado que personas con afasia (PCA) muestran mayores dificultades en los contextos anteriores. El euskera, una lengua con un sistema de alineamiento de caso de tipo ergativo-absolutivo, asigna morfología de caso ergativo a sujetos de verbos inergativos y transitivos, pero no si el verbo es inacusativo. No está claro si estos patrones de asignación de caso afectan al coste de procesamiento y desempeño en estos verbos, que también varían en el número de argumentos y en la canonicidad del mapeo de argumentos; ni cómo afectarían.

Esta tesis doctoral investiga la influencia de la marca de caso ergativo en efectos de complejidad de la estructura argumental tanto en sujetos neurotípicos bilingües euskera-español como en PCA bilingües. El coste de procesamiento asociado con el caso ergativo en euskera se evalúa junto a español e inglés, idiomas nominativo-acusativos que no emplean la morfología de caso para marcar diferentes tipos de estructuras argumentales de los verbos.

En el trabajo actual llevamos a cabo tres experimentos para poner a prueba la hipótesis de que la marca de caso ergativo en euskera aumenta el coste de procesamiento de los verbos y da lugar a diferentes efectos de complejidad de la estructura argumental que los efectos predichos para las lenguas nominativo-acusativas típicamente estudiadas, como el español y el inglés. Específicamente, hemos predicho que los verbos inergativos y transitivos con marca de caso ergativo supondrían un mayor coste de procesamiento en comparación con verbos inacusativos que asignan un caso absolutivo y carecen de una marca de caso evidente. Por otro lado, predijimos que el español y el inglés mostrarían un patrón similar, con mayores costes de procesamiento para frases transitivas, por su alto número de argumentos, y/o para frases inacusativas por su mapeo no canónico de argumentos. Empleamos un diseño intra-sujeto en una población de bilingües simultáneos euskera-español (Experimentos 1 y 2) y en PCA bilingües español-inglés y euskera-español (Experimento 3). En estos tres experimentos evaluamos el desempeño de los participantes en verbos inergativos, inacusativos, y transitivos, medidos a nivel de léxico, de oración y de discurso, tanto en producción como en comprensión. Los patrones de coste de procesamiento, cuantificados a través de múltiples medidas conductuales, se midieron y evaluaron en los diferentes idiomas.

El Experimento 1 midió el desempeño de 71 bilingües simultáneos euskera- español en los tres tipos de verbos de interés, en una tarea de decisión léxica y de producción de frases. No observamos diferencias entre los tipos verbales en la tarea de decisión léxica en las dos lenguas. Sin embargo, en la tarea de producción, los verbos inergativos del euskera provocaron más frases agramaticales que los otros tipos verbales. Además, los verbos inacusativos en español provocaron mayores tiempos de comienzo del habla (TCH) que los inergativos.

Interpretamos nuestros resultados en euskera como resultantes de la “discordancia aparente” entre la lectura intransitiva de eventos inergativos y sus propiedades morfosintácticas transitivas dictadas por el caso ergativo. Explicamos el efecto de los verbos inacusativos detectado en español a través del mecanismo de planificación adelantada debido a las propiedades de los sujetos inacusativos similares a las de los objetos directos.

Con el objetivo de aportar más evidencias sobre los patrones diferenciales del coste de procesamiento de las estructuras argumentales en diferentes lenguas, llevamos a cabo el Experimento 2, que medía el desempeño de 40 bilingües euskera-español neurotípicos en los mismos tipos verbales en un amplio abanico de tareas. Estas tareas incluyen nombrar la acción y producir oraciones en el ámbito de la producción, y en el ámbito de la comprensión la combinación de verbos e imágenes y la combinación de frases e imágenes. Un conjunto de tareas más completo nos permitió evaluar ampliamente el coste de procesamiento asociado con la marca de caso ergativo, el número de argumentos y la canonicidad de su mapeo a nivel de léxico y de oración en ambos ámbitos, producción y comprensión.

En línea con el Experimento 1, no encontramos efectos de complejidad argumental en las tareas de comprensión. En el ámbito productivo, no encontramos efectos en la tarea de nombrar acciones en euskera. Sin embargo, en la tarea de provocar oraciones en euskera, los verbos inergativos produjeron TCHs más largos que los transitivos. A pesar de no encontrar un efecto estadísticamente significativo similar en el análisis de tasas de error, observamos una tendencia destacada de mayores tasas de error en verbos inergativos que otros tipos de verbos, corroborando los hallazgos de euskera del Experimento 1. En español, los verbos inacusativos provocaron mayores tasas de error que los inergativos y SOTs más largos que verbos transitivos e inergativos en la tarea de nombrar acciones. Además, los transitivos llevaron a más errores que los inergativos en la tarea de provocar oraciones en español. Interpretamos el efecto inacusativo encontrado en español como resultante del mapeo de argumentos no canónico de los verbos inacusativos. Las discrepancias de resultados entre los Experimentos 1 y 2 a nivel de frase en español son atribuibles a diferencias de tarea y modalidad entre experimentos.

El Experimento 3 examinó la influencia del marcado de caso ergativo en el desempeño de dos PCA bilingües (PCA1: español-inglés, PCA2: euskera-español). Cada PCA fue comparado con tres sujetos control. Todos los participantes pasaron por seis sesiones (tres por idioma), en las que se evaluó su desempeño a través de tasas de error en nombrar acciones, producción de oraciones y discurso a nivel de producción, y verificación de frase-imagen e historia-imagen a nivel de comprensión. De nuevo, partíamos de la hipótesis de que el euskera llevaría a un patrón de dificultades en el procesamiento verbal diferente que el del español e inglés. En particular, predijimos que la marca de caso ergativo llevaría a mayores tasas de error en los tipos de verbo en euskera que requieren ergativo (i. e., inergativos y/o transitivos).

PCA1 mostró efectos cualitativamente similares, pero intensificados, que los de los hablantes neurotípicos. Es decir, tasas de error más altas para los inacusativos. Estos resultados sugieren que las dificultades en el habla en PCA no causan, sino que intensifican, los efectos inacusativos. El desempeño de PCA2 fue diferente a nuestras predicciones respecto al euskera. Además, su desempeño en español no es comparable a los patrones observados en PCA1 o en los bilingües euskera-español neurotípicos. Interpretamos estos resultados mixtos bien como consecuencia de la etiología del participante, o bien como resultado de su desempeño casi perfecto. Por tanto, la contribución de la marca de caso ergativo en el desempeño de PCA hablantes de euskera queda pendiente de esclarecer en estudios futuros.

En general, los resultados de los Experimentos 1 y 2 aportan evidencias empíricas novedosas, indicando que el marcado de caso ergativo puede, en ciertas condiciones, afectar significativamente al coste de procesamiento de los verbos. Interpretamos nuestro mayor hallazgo, el mayor coste de procesamiento provocado por verbos inergativos en producción de frases en euskera, como la "discordancia aparente" entre la semántica intransitiva de eventos inergativos y las propiedades morfosintácticas del caso ergativo, normalmente asociada con eventos transitivos en euskera. Con respecto al español, el aumento del coste de procesamiento de inacusativos en varios niveles de representación lingüística durante la producción es congruente con estudios previos en inglés y otras lenguas nominativo-acusativas. El coste de procesamiento mayor asociado con inacusativos en español se explica por su mapeo de argumentos no canónico. Los efectos inacusativos observados a nivel léxico (i. e., al nombrar verbos aislados) ofrece apoyo al punto de vista *lexicalista* que afirma que las configuraciones de estructuras argumentales, incluyendo sus patrones de mapeo, se codifican en las entradas léxicas de los verbos. Además, los efectos inacusativos observados al nombrar verbos van en línea con la suposición del modelo de consenso de producción del habla (Bock, 1995; Bock & Levelt; 1994; Ferreira & Slevc, 2007; Slevc, 2023), que afirma que se accede a la información de la estructura argumental, incluyendo los patrones de mapeo de argumentos del verbo, en el paso de activación del lema.

Resumiendo las contribuciones más relevantes de la actual tesis, la investigación aquí presentada es el primer intento de exploración sistemática de los efectos de la complejidad de la estructura argumental en euskera, una lengua con un sistema de convergencia ergativo-absolutivo, junto con otra lengua con una convergencia de caso nominativo-acusativo. El diseño intra-sujeto aprovecha las interesantes diferencias teóricas entre ambas lenguas de sujetos bilingües euskera-español. Esta tesis es también el primer intento de evaluar de manera extensa el efecto de la marca de caso ergativo en el coste de procesamiento de verbos con diferentes niveles de complejidad en la estructura argumental, tanto en hablantes neurotípicos como en PCA. Nuestros hallazgos novedosos implican que las lenguas con sistemas de convergencia de caso ergativo-absolutivo como el euskera no muestran los mismos patrones que las lenguas nominativo-acusativas, las comúnmente estudiadas, a nivel del procesamiento de la complejidad de la estructura argumental. Este hallazgo llama a una mayor investigación translingüística. Las diferencias en los efectos de complejidad de la estructura argumental a través de las lenguas estudiadas en todos nuestros experimentos son particularmente convincentes debido a que se evaluó a los mismos hablantes bilingües en dos lenguas con sistemas de convergencia de caso diferentes. Por tanto, los diferentes patrones de procesamiento a través de las lenguas no son atribuibles a la variación individual, ni pueden ser reducidos a factores de competencia o exposición lingüística, factores controlados por análisis exploratorios adicionales.

Puesto que los experimentos aquí presentados son el primer intento en evaluar los efectos de la marca de caso ergativo en el procesamiento de la estructura argumental, necesitamos más evidencias para corroborar las diferencias translingüísticas observadas en este trabajo. En primer lugar, estudios futuros deben centrarse en entender en detalle cómo el caso ergativo interactúa con el número de argumentos y la canonicidad del mapeo argumental, así como en entender de qué manera esta interacción afecta a diferentes ámbitos y niveles de representación lingüística. En segundo lugar, necesitamos evaluar exhaustivamente a PCA de subtipos diferentes para demostrar los efectos de la marca de caso ergativo en el desempeño en la afasia. Además, los resultados de estudios translingüísticos futuros centrados en el rol del caso ergativo en el procesamiento de la estructura argumental deberán ser debidamente integrados en los modelos actuales de producción y comprensión del habla. Por último, la tesis actual enfatiza la importancia de estudiar lenguas con convergencia nominativo-acusativa junto con lenguas con convergencia de caso ergativo-absolutivo. Las propiedades morfosintácticas únicas de las lenguas ergativo-absolutivas puede permitirnos entender múltiples factores translingüísticos implicados en la representación y el procesamiento de la estructura argumental. Para entender realmente los mecanismos del habla, lenguas diversas deben ser estudiadas sistemáticamente y el euskera es ciertamente una fuente única, poco estudiada e increíblemente rica para lograr tal fin.