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MORE THAN A MERE SEQUENCE: PREDICTIVE PROCESSING OF *WH*-DEPENDENCIES IN EARLY BILINGUALS

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Abstract

The purpose of the present study was to determine whether early bilingual Basque-Spanish speakers, who acquired Spanish by the age of 5, comprehend Spanish *wh*-dependences as effortlessly as native Spanish speakers. Given that Basque and Spanish are structurally different languages, we hypothesized that predictive processing strategies from the first language (L1) would interfere with predictive processing strategies in the second language (L2). More specifically, since Basque overtly marks the semantic role of agent/subject position, whereas Spanish overtly marks the role of patient/object position, we looked at whether the difference in overt marking of semantic roles would affect comprehension of subject *vs*. object *quien* "who" and *qué* "which" direct and embedded questions as well as subject *vs*. object relative clauses introduced by *que*. The main finding of the study is that overall early Basque-Spanish bilinguals needed more time for the comprehension of *wh*-dependencies in Spanish compared to native Spanish speakers, as indicated by statistically significant group differences in response times in 9 out of 10 conditions. The results of this exploratory study indicate that a difference in overt marking of semantic roles between the two languages affects the ease of processing of Spanish *wh*-dependencies in early Basque-Spanish bilinguals, interfering with their ability to make native-like predictions in L2.

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Keywords

• Basque language • Bilingualism • Comprehension • Predictive processing • Spanish language • Syntactic cueing • *wh*-dependencies.

1. Introduction

The idea that information processing is predictive rather than merely integrative is not new and so far it has generated important insights on various topics in cognitive neuroscience, including vision, attention, motor control, motor imagery, action understanding, music, language processing, emotional processing, executive functions, the theory of mind and so forth [1-4]. Growing evidence suggests that even though incoming stimuli are typically impoverished, noisy, and partial, they are highly structured: the brain relies on these structures to form models for making predictions, which are then matched against the incoming stimuli.

Research on sentence comprehension in adult monolingual speakers has suggested that, in addition to the immediate integration of incoming words into a syntactic structure as a sentence unfolds, predictive processing also takes place, with predictions on incoming information forming even before the information appears in the input [4-6]. According to this view, sentence processing is "driven by the predictive relationships between verbs, their syntactic arguments, and the real-world contexts in which they occur" [5, p. 247]. As for bilingual speakers, predictive processing in the second language (L2) appears to take place in highly proficient bilinguals [7]. So far, research on processing strategies in bilinguals has been largely focused on typologically non-distant languages and to some extent on typologically distant languages, but the variation in processing patterns found in bilingual speakers of distant languages has not been fully explored [8-12]. Yet, geographically close languages, even when typologically distant as for instance Spanish and Basque, may structurally influence each other [13], which in turn may have a wider effect on processing strategies in bilinguals (the author is grateful to an anonymous reviewer for this suggestion). Thus, it remains unclear whether in early bilinguals, who use typologically distant languages such as Basque and Spanish, predictive processing mechanisms in L2 operate as efficiently as in native speakers.

One goal of the present study was to determine whether young, cognitively healthy native speakers of Basque, who acquired Spanish by the age of 5, rely on the same processing strategies in comprehension of Spanish *wh*-dependencies as young, cognitively healthy native Spanish speakers. Assuming comparable accuracy scores between the two groups, we wanted to determine if there would be considerable differences in their response times (RTs). Considerable differences in comprehension RTs would indicate a difference

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in the ease of processing, which in turn may be due to a reliance on different comprehension strategies based on syntactic cueing [14]. Growing evidence suggests that syntactic cueing affects comprehension in cognitively healthy monolingual and bilingual persons, as well as in aphasic patients [15-18].

The research question investigated in the present study has merit, because Basque and Spanish are structurally different languages (section 2), and thus different syntactic cues may underpin different strategies in the comprehension of *wh*-dependencies in the two languages. If syntactic cueing strategies in L1 affect comprehension of *wh*-dependencies in L2 in early Basque-Spanish bilinguals, then predictions based on L1 will interfere with the predictions that would be made solely on the basis of L2 cues, which would result in longer RTs in bilinguals. Thus, compared to native Spanish speakers, early Basque-Spanish bilinguals may not simply "need more time" to integrate incoming information as a specific type of Spanish *wh*-dependencies unfolds, but instead they may rely on different, more time-costly comprehension strategies due to interference of predictions based on L1. The question whether predictive processing mechanisms in L1 and L2 operate on different timescales in early bilinguals is not only theoretically relevant, but also important for educational assessments as well as neurocognitive testing of populations with brain disorders.

2. Present study: linguistic background

Wh-dependencies are dependency relations between a *wh*-word, such as *what*, *who*, *which*, *why, how* etc. and another element in a sentence [19]. In syntax, a dependency relation is defined by the elements that form dependency as well as by the distance between them, which in turn depends on their syntactic hierarchy. The present study focused on direct and embedded questions introduced by interrogative pronouns *quién* ("who") and *qué* ("what, which"), and relative clauses introduced by *que*. Linguistic theory postulates that these syntactic structures involve *wh*-movement, i.e. a syntactic operation that moves a *wh*-word to a position different from the one in which it originated, leaving behind a co-indexed trace (*t*) or gap [20]. The trace contains important information on semantic ("thematic") roles, i.e. information on *who did what to whom* in a sentence (for example, *the boy* in *The boy kissed the girl* is assigned the role of agent, because *the boy* performed the action of kissing, whereas *the girl* is assigned the role of patient, meaning that *the girl* underwent the action of kissing). Crucially, the moved *wh*-phrase receives a thematic role via its trace.

In Spanish, like in English, the distance between a moved element and its gap is longer in object *wh*-structures, as in (2), than in subject *wh*-structures, as in (1):

(1) ¿Quién$_i$ t_i comió una naranja?
who ate an orange
"Who ate an orange?"

(2) ¿A quién$_i$ mordió$_j$ el perrito t_j t_i?
to whom bit the puppy
"Whom did the puppy bite?"

The preposition *a*, as in example (2), marks animate objects in Spanish [21] and therefore it could serve as a processing cue [22, 23]. Since it appears before the moved *wh*-word, it signals an object structure, allowing the parser, i.e. sentence analyzer, to assign a temporary thematic role of patient even before encountering the gap (t_i). Therefore, reliance on this cue would facilitate comprehension of object *wh*-dependencies, cancelling out the processing differences between subject and more demanding object *wh*-dependencies [24].

Unlike Spanish, which overtly marks object position in a sentence and the role of patient, as shown in (2), Basque overtly marks subject position and the role of agent, as shown in (3):

(3) Gizon-a -k emakume-a –ri liburu-a
Man the woman the book the
eman dio.
give has
"The man has given the book to the woman."
[25, p. 72].

The subject position in (3) is morphologically marked by ergative case (-*k*). Linguistic theory characterizes Basque as an ergative language and Spanish as an accusative language [26]. This means that in Spanish the subjects of transitive and intransitive verbs bear the nominative case and the object of transitive verbs bears the accusative case, whereas in Basque subjects of transitive verbs are assigned the ergative case, and subjects of intransitive and objects of transitive verbs are assigned the absolutive case [26].

Even though there is no unlimited variation in language structure, some structural differences between Spanish and Basque may be relevant to the processing question under investigation. For example, word orders differ in Spanish and Basque: Spanish is head-initial and its canonical word order is subject-verb-object (SVO), whereas Basque is head-final and its canonical word order is subject-object-verb (SOV) [26]. Furthermore, the difference in overtly marking agents (Basque) vs. patients (Spanish) may be critical in processing *wh*-dependencies in L2. In other words, the mismatch in overt marking of agents vs. patients in the two languages may affect L2 processing in early Basque-Spanish bilinguals and reveal predominance of the default L1 processing strategies.

In readily observable linear terms, the two languages share the order of appearance of these two roles in *wh*-questions, i.e. agent first, then patient in subject *wh*-questions, and patient first, then agent in object *wh*-questions. However, Spanish and Basque differ in the order of appearance of these roles in relative clauses (RCs): Spanish retains the same order in subject and object RCs as in subject and object *wh*-questions, whereas Basque reverses the order, having overtly marked agents appearing before unmarked patients in object RCs. Thus, if only the order of appearance affects comprehension strategies in bilinguals, one would expect to find group differences in RCs, but not in *wh*-questions.

In addition, since Basque does not employ the same cue in syntactic marking of animate objects that Spanish does, there is a possibility that early Basque-Spanish bilinguals do not utilize this cue in comprehension of Spanish object *wh*-dependencies. This would be indicated by their systematically slower comprehension of all object *wh*-dependencies relative to native Spanish speakers. On the other hand, early Basque-Spanish bilinguals may differ from native Spanish speakers in the comprehension of Spanish *wh*-dependencies regardless of syntactic cueing, showing generally longer response times. In this case, the bilingual group would be generally slower in all conditions compared to the native group. This would indicate that the impact of L1 syntax on comprehension of Spanish *wh*-dependencies in early Basque-Spanish bilinguals may be more complex than postulated in the previous hypothesis, involving for instance a combination of preferences in overt thematic role marking and specifics of word order.

3. Methods

Data analyzed in the present study was collected within a larger study on comprehension cuing strategies in elderly Spanish speakers [24]. Unlike the present study, which is focused on the comprehension of *wh*-dependencies in young Basque-Spanish bilinguals, the previous study on elderly persons' comprehension of *wh*-dependencies did not investigate the potential effects of bilingualism.

3.1 Participants

Eighteen cognitively healthy, highly educated young persons with no history of stroke, neurological disorders, alcohol/drug abuse, or other conditions that could affect cognition participated in the study. They all reported normal hearing, and normal or corrected-to-normal vision. All participants spoke Spanish as the dominant language since the age of 5. One half were early Basque-Spanish bilinguals and the other half were native Spanish speakers. Participants' characteristics are summarized in Table 1.

3.2 Evaluative measures

Evaluative tests used in the present study served to confirm that the participants had normal cognitive status and comparable verbal working memory capacity. Briefly, we administered the Montreal Cognitive Assessment (MoCA) [27] as a test of global cognition. Only participants who scored 26 or higher on this test were eligible for the study. Since working memory capacity affects sentence comprehension [28,29], we administered the Month Ordering Test to assess participants' verbal working memory capacity. This test assesses the storage and manipulation of material with semantic content, i.e., the names of the months in the calendar, which makes it highly relevant for studies of sentence comprehension [30]. The months are given in a non-canonical order and the task is to repeat them canonically. There are 20 strings of months in total, distributed across 5 levels, containing a different number of months to order, with 4 strings of equal numbers of months at each level. Each correctly ordered string is scored as one point. Thus, the total possible score is 20. Participants' scores on evaluative measures are listed in Table 1.

The two groups did not differ considerably in age ($t(16) = 1.26$, $p = 0.22$), years of education ($t(16) = 0.23$, $p = 0.82$), verbal working memory capacity ($t(16) = 0.76$, $p = 0.46$), or global cognitive status ($t(16) = 0.19$, $p = 0.85$).

3.3 Experimental measures

The study included three experiments. Examples of stimuli for each experimental condition are listed in Table 3.

Experiment 1 tested the comprehension of *who* and *which* direct questions (DQs) extracted from the subject and object position in a sentence (n = 40). Experiment 2 tested the comprehension of embedded questions (EQs) (n = 40), manipulating the same variables as Experiment 1 (subject/object, *who/which*). Experiment 3 tested the comprehension of relative clauses (RCs) introduced by *que* (n = 20; 10 subject and 10 object RCs). Each question/RC was preceded by a brief context. The sentences were presented auditorily, and two answers were offered in written form on a computer screen. The participants indicated their responses by pressing the left or right arrow on the keyboard, depending on whether the correct answer was on the left or on the right side of the screen.

Sentence stimuli for each experiment were first randomized in Microsoft Excel and

Table 1. Participants' profile.

Study ID	Gender	Age	Hand	L1	Edu	MoCA	VWM
Y01	M	25	Amb	Spanish	20	30	18
Y02	M	24	R	Basque	17	28	16
Y03	F	25	L	Basque	13	28	13
Y04	F	26	R	Spanish	18	29	12
Y05	F	20	R	Spanish	15	27	17
Y06	F	23	R	Basque	18	30	18
Y07	F	22	R	Spanish	16	27	12
Y08	F	25	R	Basque	18	27	17
Y10	F	24	R	Basque	18	30	17
Y09	F	28	R	Basque	20	30	16
Y11	F	20	R	Spanish	15	30	18
Y12	F	22	R	Basque	16	27	14
Y13	M	25	R	Spanish	17	29	15
Y14	M	25	R	Spanish	18	30	16
Y15	F	28	R	Basque	18	29	15
Y16	F	30	R	Basque	20	30	14
Y17	F	25	R	Spanish	17	29	12
Y18	F	27	R	Spanish	20	29	13

M, male; F, female; Hand, handedness; L, left; R, right; Amb, ambidextrous; L1, first acquired language; Edu, years of formal education; MoCA, Montreal Cognitive Assessment; VWM, verbal working memory.

then recorded in Audacity (http://audacity.sourceforge.net/). Pre-recorded sentences were imported in DMDX scripting tool (www.http://www.u.arizona.edu/~kforster/dmdx) and presented auditorily over a PC computer and a set of speakerphones.

3.4 Procedures

Before beginning the experiments, each participant successfully completed eight practice trials. Participants were instructed to respond as quickly and as accurately as possible. The next sentence was initiated by the participant's response. The left and right positions for correct answers were counter-balanced in each condition in all experiments. The time window for answers was 5,000 msec. If the participant did not respond within that time, the answer options disappeared from the screen, and a fixation cross appeared, indicating that a new auditory stimulus was about to start. A failure to respond within 5,000 msec was scored as an error. There was a 30-second break after every 20 sentences. No feedback was provided during testing. Testing was carried out in a quiet room, individually with each participant, and was completed in a single session, which lasted approximately one hour and ten minutes. All participants signed informed consent. The study was conducted in accordance with the Declaration of Helsinki guidelines for studies involving human subjects and was approved by the local ethics committee.

4. Results

Accuracy. The binomial test revealed that 3 out of 180 scores (18 participants x 10 conditions), or 1.7%, were at the chance level. The binomial distribution test was used to calculate the likelihood of obtaining a certain score on the experimental measures. Chance performance was calculated as the distribution of the binomial with p = 0.5, because the participants selected one of the two offered answers. The scores of 3-7 indicate chance level and scores of 8-10 indicate above chance level task performance. The percentage correct scores relative to chance are summarized in Table 4.

Table 2. Median RTs (in milliseconds) for all conditions. All tests are two-tailed.

Wh-structure	Basque (median)	Spanish (median)	U	P
Who-S-DQ	675.92	545.41	2570	< 0.000
Who_O_DQ	684.72	530.91	2209	< 0.000
Whi_S_DQ	639.2	448.5	2564	< 0.000
Whi_O_DQ	626.24	450.37	2018	< 0.000
Who_S_EQ	369.44	375	3838	0.54 (n.s.)
Who_O_EQ	478.38	347.41	3303.5	0.033
Which_S_EQ	398.58	321.98	2867	0.001
Which_O_EQ	460.64	312.13	2681	< 0.000
RC_S	460.47	339.40	3039.5	0.004
RC_O	442.13	347.19	3174	0.012

S, subject; O, object; DQ, direct questions; EQ, embedded questions; RC, relative clauses.

Table 3. Examples of experimental stimuli.

Wh-dependency	Spanish example	Answers (correct in bold)	
Who-subject-DQ	Los niños están en la playa. Juan leyó un libro y Pepe leyó una revista. ¿Quién leyó una revista?	Juan	**Pepe**
Who-object-DQ	Los niños están jugando con un gatito. El gatito lamió a Juan y arañó a Pepe. ¿A quién lamió el gatito?	**Juan**	Pepe
Which-subject-DQ	Las niñas están jugando. Ana pateó una pelota y María bañó una muñeca. ¿Qué niña pateó una pelota?	**Ana**	María
Which-object-DQ	Las niñas están en el zoológico. El mono asustó a Ana y entretuvo a María. ¿A qué niña entretuvo el mono?	Ana	**María**
Who-subject-EQ	Pedro sabe quién llamó al doctor desde la oficina. Alguien llamó al doctor.	**Verdadero**	Falso
Who-object-EQ	Pedro sabe a quién besó la vendedora en la oficina. Alguien besó a la vendedora.	Verdadero	**Falso**
Which-subject-EQ	Pedro sabe qué niño besó a la vendedora en la oficina. Algún niño besó a la vendedora.	**Verdadero**	Falso
Which-object-EQ	Pedro sabe a qué cliente criticó el vendedor por la tarde. Algún cliente criticó al vendedor.	Verdadero	**Falso**
RC-subject	Mamá y la tía están cosiendo. Mamá hizo un vestido y la tía se lo probó. La mujer que hizo el vestido es mamá.	**Correcto**	Incorrecto
RC-object	Las chicas están en el colegio. El director felicitó a Ana y regañó a María. La chica a la que el director regañó es Ana.	Correcto	**Incorrecto**

DQ, direct questions; EQ, embedded questions; RC, relative clauses.

The groups achieved comparable accuracy scores in all conditions, except on embedded object *who* questions, where the bilingual Basque-Spanish group had a lower score (U = 15.5, p = 0.02, two-tailed). Since the tests allowed only a limited amount of time for answers, i.e., 5000 ms, we interpreted this result as an indicator that the Basque-Spanish bilinguals needed more time to process embedded object *who* questions.

Response times. In addition, the Basque-Spanish bilingual group needed considerably more time to process 9 out of 10 types of *wh*-structures, as indicated by statistically significant group differences in RTs (Table 2).

Table 4. Percent correct scores for all participants on all sentence types.

ID	Who-S-DQ	Who-O-DQ	Whi-S-DQ	Whi-O-DQ	Who-S-EQ	Who-O-EQ	Whi-S-EQ	Whi-O-EQ	RC-S	RC-O
Y01	100	100	100	90	100	100	100	80	100	100
Y02	100	100	100	90	100	80	100	90	90	80
Y03	100	100	100	100	90	90	90	100	100	90
Y04	90	100	100	90	100	80	80	90	100	70*
Y05	100	90	100	90	100	100	100	80	100	100
Y06	100	100	100	100	100	90	100	100	100	100
Y07	100	100	100	100	100	100	100	100	100	100
Y08	100	100	80	100	90	90	80	60*	100	100
Y09	100	100	100	100	90	100	100	100	100	100
Y10	90	100	90	100	100	100	100	100	90	100
Y11	100	100	100	100	90	100	100	100	100	100
Y12	100	100	100	100	90	70*	100	100	100	100
Y13	90	90	100	80	90	100	100	100	100	90
Y14	100	100	90	100	90	100	100	80	90	100
Y15	100	100	100	100	90	90	90	100	100	90
Y16	90	90	80	90	90	90	100	80	90	100
Y17	70	90	90	100	90	100	100	100	80	100
Y18	100	100	100	100	100	100	100	100	90	100

Basque-Spanish bilinguals are highlighted. The * indicates the chance level performance.

5. Discussion

Empirical testing of how an early age of acquisition of a language typologically distant from the native language interacts with the processing of specific principles of L2 syntax is yet to provide conclusive evidence on the extent of transfer from the L1 into L2 [31]. The purpose of the present study was to determine whether early bilingual Basque-Spanish speakers who acquired Spanish by the age of five comprehend *wh*-dependences in L2 with the same ease as native Spanish speakers. The main finding of the present study is that overall, the early Basque-Spanish bilinguals needed more time for the comprehension of Spanish *wh*-dependencies relative to native Spanish speakers. This is indicated by statistically significant group differences in RTs in 9 out of 10 conditions across three types of *wh*-dependencies. Since the tests allowed only a limited amount of time for answers, i.e., 5000 ms, the need for more time also affected accuracy, although in only one condition - object *who* embedded questions - resulting in a significantly lower score in the bilingual group. Given the lack of statistically significant group differences on the test of verbal working memory capacity (section 3.2), the longer RTs in bilinguals cannot be explained in terms of limited verbal working memory capacity that would affect syntactic analysis of the input in L2. Instead, the group differences appear to be due to differences in processing strategies.

The present findings clearly rule out the notion that early Basque-Spanish bilinguals comprehend Spanish *wh*-dependencies with the same ease as native Spanish speakers and they mostly agree with previous studies that indicate the effects of early setting of syntactic parameters in L1 on L2. Furthermore, the present study results argue against the hypothesis that early Basque-Spanish bilinguals use completely different processing strategies relative to native Spanish speakers because, if true, it would yield considerable group differences on all conditions, with no exemptions. Instead, the present data suggests that L1 strategies may interfere to some degree with the comprehension of Spanish *wh*-dependencies in early Basque-Spanish bilinguals. The interference appears to reflect competing comprehension strategies, motivated by the differences in native and nonnative morphosyntax. Since Basque and Spanish are structurally different languages, with different word orders (SVO, SOV) and differences in overt marking of thematic roles, it is not surprising that predictive processing strategies from L1 interfere with predictive processing strategies in L2, slowing down comprehension in L2 and, in paradigms with sufficiently limited time to respond (as in the present study), also affecting accuracy. Our data indicates a salient role of overt marking of thematic roles in these strategies and no apparent role of their linear order.

Regardless, the differential overt marking of agents vs. patients cannot explain a small portion of our data, i.e. lack of statistically significant group differences in RTs on embedded *who* subject questions: Basque systematically marks agents and Spanish systematically marks patients in this type of *wh*-dependencies as well. The result cannot be explained in terms of discourse linking [32], which assumes systematic differences between discourse-linked *which* questions and non-discourse-linked *who* questions, because of slower processing times of all other *who* questions and all *which* questions in early Basque-Spanish bilinguals. In addition, the relatively small number of participants per group indicates caution in the interpretation of present findings. Thus, the actual extent of L1 interference with the comprehension of Spanish *wh*-dependencies in early Basque-Spanish bilinguals requires further studies with larger samples, and the use of more nuanced experimental paradigms.

For example, mainstream psycholinguistics holds that bilingual speakers, even when they use only one language, retain simultaneous activation of both languages [33-34]. This evidence comes mostly from research investigating representations up to the lexical level. These representations contribute to higher levels of processing, including syntactic computations and representations. Yet, the simultaneous and continuous activation of two languages is cognitively costly and it violates the most basic principle of cognitive economy. This is particularly relevant for studies investigating syntactic representations in bilinguals. Some recently put forth proposals postulate that syntactic representations in L1 and L2 are shared between languages, providing evidence, for instance, from syntactic priming in speech production [35] and connectionist modeling of word-level comprehension [36]. However, it remains unclear how exactly co-activated or shared syntactic representations from L1 and L2 interact during spoken L2 comprehension to yield considerably slower sentence-level processing in L2 in early bilinguals. To tease apart the aspects of this interaction, future studies will focus on determining electrophysiological correlates of overt thematic role marking and other relevant predictive processes' timescales in early Basque-Spanish bilinguals.

In conclusion, the purpose of the present study was to determine whether early bilingual Basque-Spanish speakers comprehend *wh*-dependences in L2, which they had acquired by the age of 5, with the same ease as native Spanish speakers. Early exposure to L2 appears to affect a person's capacity to master an L2 [37], structural plasticity of the bilingual brain [38] and the neural correlates of L2 grammar processing [39]. The present study finding that syntax in L2 may not be processed with native-like ease, even when L2 is acquired before the age of 5, is consistent with the notion that differences in processing patterns [12,40] may be more emphasized in speakers of typologically more distant languages (Indo-European such as Spanish vs. non-Indo-European such as Basque), affecting predictive processing in L2. The finding is also highly relevant for the discussion on whether syntax is separate or shared between languages in bilinguals, because it raises questions on how specific features of grammar, such as overt marking of thematic roles, co-operate and compete in typologically distant languages.

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