This is a contribution from *Variation and Evolution. Aspects of language contact and contrast across the Spanish-speaking world*.
Edited by Sandro Sessarego, Juan J. Colomina-Almiñana and Adrián Rodríguez-Riccelli.

CHAPTER 3

A corpus analysis of the structural elaboration of Spanish heritage language learners

Karina Collentine and Joseph Collentine
Northern Arizona University

Research on heritage language learner (HLL) grammar provides insights into bilingual developmental trajectories (Bolger & Zapata, 2011). More research is needed on the effects of cognitive processes on HLL grammar under real-time communicative pressures (Jegerski, 2017). The present corpus-based study analyzes the role of cognitive factors on HLLs' ($N = 65$) production of structural elaboration (i.e., syntactic modifiers and embedding), which is cognitively challenging to monolinguals (Ferreira, 1991). The analysis of the participants' production in an instant-messaging task indicates that, even though advanced HLLs may be fairly homogeneous in their general grammatical and lexical abilities, they vary significantly in the production of structural elaboration in syntactic frames (e.g., verb phrases with clitics, relative clauses) that interact strongly with working memory and attentional resources.

Keywords: heritage language learners, corpus, structural elaboration, cognition, Spanish

1. Introduction

Research on heritage language learner (HLL) grammar provides insights into the type(s) of linguistic knowledge that bilinguals possess, the effects of environment on such knowledge, and how bilingualism affects generalized reasoning and logical abilities (Bolger & Zapata, 2011; Jegerski, 2017). HLLs are also students in university-level Spanish programs, and their enrollments are growing. Second language acquisition (SLA) research in the last 30 years indicates that language development is more than acquiring grammatical and lexical knowledge. Instructional techniques involving structured input and input enhancement consider the role of cognitive processes in comprehension and production. HLL researchers are just beginning to understand the role that cognitive factors play in HLL production.

https://doi.org/10.1075/ihll.29.03col

The present corpus-based study entailing instant-messaging data contributes to our understanding of how cognitive factors interact with HLLs' production of structural elaboration (i.e., syntactic modifiers and embedding).

2. Literature review

2.1 Core and peripheral grammatical knowledge of advanced heritage language learners

Core syntactic phenomena develop with principles and parameters (e.g., ± pro drop) of Universal Grammar (UG). Non-core (i.e., peripheral) phenomena involve language specific phenomena, such as inflectional morphology (e.g., gender, mood). Spanish HLLs demonstrate the same knowledge of wh-movement restrictions that monolinguals demonstrate (Montrul, Foote, & Perpin, 2008). Consequently, most Spanish HLLs have superior implicit knowledge of fundamental grammatical restrictions (e.g., movement, case assignment, anaphoric reference) compared to non-HLL learners (Bowles, 2011). For example, in writing, Spanish HLLs produce the same number of complex syntactic structures (e.g., T-Units) as monolinguals do (Sánchez Abchi & De Mier, 2017). Low proficiency Spanish HLLs distinguish surprisingly well between unaccusative (e.g., *María [patient] se cayó* 'Maria fell') and unergative (e.g., *María [agent] lloró* 'Maria cried') verbs (Montrul, 2006).

Although advanced Spanish HLLs' core syntactic competence is like that of a monolingual Spanish speaker, their use of inflectional morphology and pragmatics often differs. For example, advanced proficiency HLLs demonstrate variable use of differential object marking (e.g., **Juan vio María* 'Juan saw Maria' instead of *Juan vio **a** María*; see Montrul & Bowles, 2009) and subject-verb inversion in subordinate clauses (e.g., *No sé adónde Juan fue* 'I do not know where Juan went' instead of *No sé adónde fue Juan*; see Bruhn de Garavito, 2002). This may occur because the interface between core and non-core language modules can be weak (Montrul & Polinsky, 2011; Pascual y Cabo & Gómez Soler, 2015). For non-core language modules such as those responsible for inflectional morphology and pragmatics to function as they are thought to among monolinguals, the interface between these knowledge stores and the syntactic module must be tightly connected (Sorace, 2011). For instance, mood selection (e.g., indicative/subjunctive) in subordinate clauses requires rapid and coordinated processing of features within and between the syntactic, morphological, and pragmatic modules.

2.2 On the need to expand our understanding of the cognition of HLL performance

HLL research has focused on how bilinguals coordinate the knowledge of two languages, how the languages influence each other, and how multilingualism affects domain-general cognitive functions, such as logical reasoning (Kroll, Dussias, Bice, & Perrotti, 2014). In general, research on bilingualism is concerned with the "cognitive representation of bilingual language knowledge" (Reif & Robinson, 2016, p. 23). Research on HLL grammar focuses on developmental trajectories, such as the consequences of limited access to the TL, attrition, and dominant-language influence (Benmamoun, Montrul, & Polinsky, 2013; Jegerski, 2017; Scontras, Fuchs, & Polinsky, 2015). Research has assessed HLLs' implicit (metalinguistic) knowledge with offline tasks, such as sentence-completion tasks, and grammaticality judgements (cf. Jegerski, 2017). To increase our understanding of advanced HLLs' grammatical knowledge and abilities, we need more research that depicts HLL performance under the cognitive pressures of real-time communication, such as in conversational interactions (Bolger & Zapata, 2011; Jegerski, 2017).

Researchers are beginning to understand how HLLs manage cognitive processes such as attention and working memory when they use morphological and syntactic knowledge, which varies in degree of proceduralization (Bolger & Zapata, 2011). Recent psycholinguistic research provides important insights into the interaction between processing (e.g., attentional resources, phonological memory) and HLLs' interpretation of structurally complex phenomena (Jegerski, 2017; Kroll et al., 2014). Processing mechanisms may play a more important role in HLLs' interpretation of grammatical properties than previously expected. Keating, VanPatten and Jegerski (2016) speculate that HLLs' interpretation of overt subject pronouns is more variable than that of monolinguals. Keating et al. (2016) report that, in real time, whereas monolinguals consistently interpret subject pronouns like *él* in sentences such as *Después de que el ladrón habló con el policía, **él** hizo unas llamadas* 'After the thief spoke with the police, he made some telephone calls' as referring to *el policía*, HLLs exhibit significant variability. While Keating et al. (2016) surmise that HLLs may represent overt subjects differently in the linguistic knowledge than monolinguals do, they also surmise that cognitive processing may explain their data. It may be that overt-subject assignment taxes HLLs' management of attentional resources and memory stores because it entails "the rapid and complex integration of various sources of linguistic information in real time" (p. 46). Additionally, Jegerski (2018) speculates that some HLLs' interpretation of relative-clause antecedents (e.g., *Mi tío vio a la hermana de la mujer* ***que*** *vivía calle abajo* 'My uncle saw the sister of the woman who lived down the street') can be variable because of either language transfer or because processing resources become taxed.

To contribute to our understanding of the interaction between HLLs' cognitive processing and their Spanish grammatical knowledge, the present study focuses on HLLs' production of structural elaboration. Formally speaking, structural elaboration involves complex syntactic phenomena such as subordination (e.g., nominal, restrictive, and adverbial clauses) and modifiers of basic syntactic nuclei, such as adjectives and determiners modifying nouns (e.g., *todas las otras casas, una ciudad antigua* 'all the other houses, an old city'), adverbs modifying adjectives (e.g., *muy antigua* 'very old'), or prepositional phrases modifying nouns (e.g., *una casa sin jardín* 'a house without a garden'). Cognitively speaking, structural elaboration tends to be costly. According to Housen and Simoens (2016), subordination and modification require that attentional resources and working memory manage various phrase-structure, morphological, and semantic features. Monolinguals require *exponentially* more time to produce an elaborate phrase structure than a relatively simple one (Ferreira, 1991). Even when controlling for word counts, monolinguals require exponentially more time to produce an NP with, for example, two determiners and an AdjP (e.g., *toda una casa nueva* 'a whole new house') than they need to produce a relatively simple NP with a determiner and a noun (e.g. *una casa* 'a house'). That is, structural elaboration does not simply entail the production of additional words; it also entails processing morphosyntactic relationships within and across phrases and constituents. Structural elaboration with subordination and modification increases the propositional content and specificity connoted by simple verbs and nouns, thus adding a layer of functional complexity (Housen & Simoens, 2016). Additionally, such elaboration requires the use of non-core knowledge structures (whether they represent implicit or explicit knowledge) that are less automatized than core structures, which is especially costly in spontaneous, meaningful production (DeKeyser, 2016; Housen & Kuiken, 2009).

2.3 Expanding the pool of HLL data

Researchers are encouraged to study linguistic development with multiple data sources (Norris & Ortega, 2009). To understand the effects of cognitive mechanisms on HLL grammatical processing, Jegerski (2017) argues that we need more data reflecting implicit linguistic knowledge. Techniques targeting HLLs' explicit knowledge of Spanish grammar may not accurately depict grammatical competence. Jegerski (2017) emphasizes that research can increase its ecological validity with techniques that are "meaning-based to the greatest extent possible" (p. 230). We submit that corpus-based research can both complement current HLL research and increase its ecological validity by providing insights into HLLs' competence with data from spontaneous, meaningful interactions under ever-present conversational and pragmatic pressures (cf. Meyer, Alday, Decuyper, & Knudsen, 2018).

3. Research questions

The present investigation presents a corpus-based analysis of the extent to which HLLs vary in structural elaboration in spontaneous and meaningful production, and the possible cognitive factors that affect elaboration. The study asks:

– What are the types of structural elaboration exhibited by advanced HLLs in spontaneous and meaningful production?
– What are the probable cognitive explanations for the types of structural elaboration exhibited by advanced HLLs?

3.1 Method

3.1.1 *Participants*

The HLLs (N = 65) on whose data this study reports participated in a task-based study that we recently completed (K. Collentine, 2018; Collentine & Collentine, in press). However, their data have not been reported to date since the focus of previous studies was adult second-language (L2) learners (See *Task and corpora* below.) Each HLL was enrolled in a university-level, foreign-language Spanish course at the third year from a mix of grammar (n = 21), conversation (n = 14), and composition courses (n = 30). According to an intake survey, the HLLs ranged from ages 18 to 25 and were mostly of Mexican descent (n = 55), although some reported Salvadoran (n = 3), Guatemalan (n = 5), and Honduran (n = 2) descent. All were raised in the US and reported Spanish spoken at home. The dominant language of their schooling was English, and all self-reported English as their dominant language. Some participants were simultaneous bilinguals (n = 20), although the majority were sequential (n = 45), experiencing their first immersive exposure to English after age five (6–11 years).

To contextualize objectively the HLLs' Spanish abilities, we compare their performance on four measurements of linguistic complexity to measurements resulting from a monolingual comparison corpus (See *General assessment of HLLs' proficiency* below).

3.1.2 *Task and corpora*

The HLL corpus resulted from a task representing spontaneous interactions. Within a virtual world designed by the researchers with Unity 3D (unity3d.com), students needed to identify the thief of a stolen relic. For 15 minutes, students explored an open-air marketplace (e.g., with vendors, stores, a restaurant, a café) containing interactive avatars that were customers and store owners. Students gathered information about the avatars, such as their name, their reason for being at the marketplace, and whether they witnessed anything relevant to the crime. Upon approaching an avatar, a screen appeared with buttons that students could click to choose the questions they wanted to pose. Upon clicking a question button, students read an avatar's response. Students could return to a place or an avatar as much as they wanted. To lessen the need to memorize names, head shots and names of each avatar appeared at the bottom of the screen anytime a question-answer screen was prompted.

Students then participated in a synchronized computer mediated communication (SCMC) segment, lasting 25 minutes. In a Moodle instant-messaging chatroom, randomly assigned dyads shared in Spanish clues they collected. Dyads were tasked with reaching a consensus about who the culprit might have been. Dyads' interactions were archived to a database. All of the participants reported having experience using both virtual-world gaming and instant messaging. This HLL corpus consisted of 14,595 words (files = 65, mean words per interlocutor = 224.5, *SD* = 100.2).

SCMC, like oral conversation, requires that interlocutors manage cognitive resources at the same time that they must process linguistic form and meaning. According to Stockwell (2010), "SCMC is generally considered to place a greater load on learners [than asynchronous modes of communication] in that learners have less time to react and respond to input" (p. 84). It should be noted that, while SCMC contains many of the discursive features of conversations, SCMC does allow for slightly longer processing times than conversational interaction (Arroyo & Yilmaz, 2018).

Although we did not have an instant-messaging monolingual corpus with which to compare the HLL corpus, we built a monolingual corpus whose discursive characteristics approximated the SCMC portion of the task. We randomly sampled the *Corpus del español* reported in Biber, Davies, Jones, & Tracy-Ventura (2006), extracting short-oral interview documents (*N* = 65). This corpus consisted of 32,134 words (files = 65, words = 32,134, mean words per interlocutor = 494.4, *SD* = 330.1). We surmise that the sample was comparable because meaning is derived through negotiation and in real time in both SCMC and conversation (Arroyo & Yilmaz, 2018; Stockwell, 2010). Oral-interviews and SCMC are also similar since both favor the use of verbs and subordination to relate and connect events (Biber et al., 2006; Collentine & Collentine, in press). Additionally, SCMC contains features of oral communication, such as ellipsis and informality (Arroyo & Yilmaz, 2018).

3.2 General assessment of HLLs' proficiency

We assessed the HLLs' Spanish proficiency by comparing their structural and lexical complexity to that of monolinguals (cf. Bulté & Housen, 2012). We use four metrics that do not constitute elaboration: (i) clauses per turn, (ii) words per clause, (iii) lexical words to function words, and (iv) the measure of textual lexical diversity.

We authored Python scripts and used the Natural Language Tool Kit (NLTK; Bird, Loper, & Klein, 2009) to assess structural complexity by calculating *clauses per turn* and *words per clause*, which are common measures of syntactic sophistication in interactive production (Collentine & Collentine, in press; Bulté & Housen, 2012). We utilized the R package koRpus (Michalke, 2018) to measure *lexical words to function words*, which estimates the importance of content words (i.e., nouns, verbs, adjectives, and adverbs). We also used koRpus to calculate the *measure of textual lexical diversity* (MTLD), which estimates breadth of vocabulary while largely avoiding the text-length effects of type-token ratio (TTR).

Table 1. HLL and monolingual comparison corpus linguistic complexity

Measure	**HLL**	**Monolinguals**	**Unpaired sample t-tests of significance**
– Clauses per turn	$M = 0.83$ ($SD = 0.36$)	$M = 0.89$ ($SD = 0.36$)	$t = 1.04$, $df = 128$, $p = 0.30$
– Words per clause	$M = 5.89$ ($SD = 1.56$)	$M = 6.44$ ($SD = 0.75$)	$t = 2.57$, $df = 128$, $p = 0.01$
– Lexical to function words	$M = 0.98$ ($SD = 0.16$)	$M = 1.11$ ($SD = 0.16$)	$t = 4.75$, $df = 128$, $p < 0.001$
– Measure of textual lexical diversity	$M = 72.72$ ($SD = 11.70$)	$M = 82.44$ ($SD = 15.10$)	$t = 4.10$, $df = 128$, $p < 0.001$

At first glance, the HLLs and the monolinguals performed similarly, although the HLLs demonstrated less complexity across three of the four metrics. Statistically, the HLLs and the monolinguals produced the same number of clauses per turn, such that they approximated that of monolinguals. However, the HLLs produced fewer words per clause, and on both lexical measures the HLLs were less complex.

3.3 Tagging and parsing

We analyzed structural elaboration in the two corpora with morphological tagging and syntactic parsing with Python scripts and NLTK. Through an iterative process of word tokenization, dictionary lookups, disambiguation, probabilistic morphological assignment and manual accuracy checking, the software routines analyzed each word for class (e.g., adjective, noun, verb, determiner, preposition) along with inflectional properties such as gender, number, person, tense and mood (e.g., *pienso;*v_pres_1s, *estuvieras;*v_impsubj_3s, *vaso;*n_ms). The syntactic analysis entailed constituent parsing. We designed a regular-expressions parser with NLTK to produce syntactic tree objects, which groups tagged words into phrasal constituents (e.g., *[NP [Det las] [N huellas]] [VP [V son] [PP [Prep de] [NP [Det ese] [N hombre]]]]*).

3.4 Analysis

To answer the research questions, the analysis identified clusters of HLLs that differ in terms of degree of structural elaboration and which could be explained by cognitive processing factors. This involved four steps.

First, we identified a heterogeneous set of syntactic frames (i.e., phrase structures) to characterize a range of structural-elaboration behaviors. The resulting 20 syntactic frames included core constituent types: noun, prepositional, adjectival, and verb phrases with and without clitic pronouns. They also included various types of adverbial phrases (e.g., location, time, pragmatic agreement, manner). The syntactic frames also targeted embedding: nominal, relative, and a variety of adverbial clauses (time, purpose, contingency, causal, etc.).

Second, to compute elaboration in each syntactic frame type (for each file in the HLL and in the monolingual corpus), we designed Python scripts that tabulated the average number of nodes (e.g., [Det …], [AdjP …]) that were not the nucleus of a noun, verb, adjectival, adverbial, prepositional phrase or of a subordinate clause. For instance, if a targeted syntactic frame was a noun phrase and one produced [NP *[Det* los *]* [N artefactos] *[SAdj* perdidos*]*], the elaboration count would be two. If a target was a relative clause and one produced [RelC [C'que] [[*VP* son [*AdjP* [*Adv* muy] [*Adj* grandes]]]]], we analyzed the subordinating conjunction as the nucleus, such that the elaboration count would be four. Thus, to estimate hierarchical elaboration in a straightforward fashion, the methodology counted both phrase structure (i.e., adjectival phrases, noun phrases, determiner phrases, clitic phrases, verb phrases, adverbial phrases, prepositional phrases, nominal, relative and adverbial clauses) and words (i.e., adjectives, nouns, determiners, pronouns, verbs, adverbs, prepositions, and subordinate conjunctions) that accompanied a nucleus.

Third, we sought to derive empirically motivated (i.e., a posteriori) models of monolingual elaboration with which we could compare HLL elaboration patterns. We assume that a monolingual comparison model can represent structural elaboration where cognitive resources and linguistic knowledge are managed without bilingual effects (e.g., language dominance, onset of L2 acquisition). Principal component analysis (PCA) identified macro (i.e., multivariate) measures of monolingual syntactic elaboration. PCA is an exploratory statistical procedure that reduces a set of candidate variables (i.e., the 20 syntactic frames) to a parsimonious set of linear equations. We consider each PCA equation to represent a *macro elaboration pattern* in the monolingual corpus. Each variable (i.e., syntactic frame) of an equation is weighted in terms of importance (e.g., frequency, its correlation or lack thereof with other variables) (Tabachnick & Fidell, 2012). For example, a linear equation might combine adjective phrase (AdjP) and prepositional phrase

(PP) elaboration, with the former being weighted more than the latter. PCA can reduce a set of 20 or so variables to a set of 3 to 4 macro variables (i.e., principal components), each of which weighs one of the original 20 or so differently. PCA also entails quality control procedures that eliminate extraneous variables. For instance, the procedure might determine that adverbs of manner were numerically unimportant in the monolingual corpus, or that causal adverbial clauses (e.g., … *porque*…) were too pervasive in the corpus to serve as a distinguishing variable. It should also be noted that the liberal approach to tabulating elaboration described above effectively biases the PCA toward identifying important macro elaboration patterns without establishing an arbitrary numeric cutoff for what constitutes a good amount of elaboration. Syntactic frames that have little elaboration will have low scores and low variances, which lessens the likelihood of their inclusion in any equation.

Fourth, with the help of k-means cluster analysis (Tabachnick & Fidell, 2012), we utilized the HLLs' mean syntactic frame counts from the second step and the monolingual *macro elaboration pattern* equations derived from the third step to identify clusters of HLLs differing in degree of structural elaboration. K-means cluster analysis allows us to distinguish between groups of HLLs based on the structural-elaboration patterns identified in the monolingual corpus. It identifies minimally heterogeneous (i.e., low variance) groupings of HLLs. To understand the grouping process, it is important to consider that, for each HLL, a score was calculated for each of the *macro elaboration pattern* equations (see Section 4). As a simplified (fictitious) example, suppose that the monolingual PCA analysis yielded three *macro elaboration pattern* equations, and one equation was (AdjP × 0.67) + (PP × 0.39). If an HLL's mean elaboration count was 1.3 for AdjPs and 3.6 for PPs, the participant's score for this macro elaboration pattern would be: (1.3 × 0.67) + (3.6 × 0.39) = 2.28. The same participant might score 1.8 and a 0.9 on the other two equations. If another HLL participant scored, respectively, 2.3, 1.7, and 1.0, then the k-means analysis might group these two HLLs together. If a third HLL participant scored, respectively, 1.3, 3.0 and 4.0, s/he might be placed into a different group.

4. Results

Regarding the identification of *macro elaboration patterns* in the monolingual corpus, the minimum counts to conduct PCA for each of the 20 initial syntactic frame types were met ($n > 9$). The syntactic frame type variables (i.e., the monolinguals' average number of non-nuclear nodes for each syntactic frame type) were examined for residual normality, and a Log10 transformation was applied to the dataset to correct for positive skewness. To identify clusters of features that reliably co-occur in the dataset and to avoid spurious results, the PCA included only syntactic frame type variables with a shared common variance of at least 45% (Tabachnick & Fidell, 2012). This approach reduced the candidate variables to ten (see Table 2).

Table 2. Descriptive statistics of variables included in monolingual PCA

Syntactic frame type	**Documents containing**	**M**	**SD**
Clause: Nominal	66	5.16	0.63
Clause: Relative	66	4.82	0.53
Prepositional Phrase	66	3.18	0.16
Verb Phrase w/Clitic	66	3.05	0.04
Noun Phrase	66	2.15	0.05
Adjectival Phrase	66	2.11	0.06
Verb Phrase	66	2.05	0.02
Adverbial Phrase: Pragmatic agreement (e.g., *muy bien*)	65	1.97	0.25
Adverbial Phrase: Time	65	1.97	0.25
Adverbial Phrase: Location	57	1.72	0.70

We extracted three principal components (PCs) based on an assessment of communalities and scree plots of components' Eigen values (see Table 3).

Table 3. Component matrix: Monolingual elaboration

Syntactic frame type	**PC1**	**PC2**	**PC3**
% of Variance	*29%*	*18%*	*13%*
Clause: Relative	0.92		
Prepositional Phrase	0.87		
Clause: Nominal	0.81		
Noun Phrase	0.70		
Verb Phrase w/Clitic		0.90	
Verb Phrase		0.87	
Adverbial Phrase: Location			0.64
Adjectival Phrase			0.56
Adverbial Phrase: Pragmatic agreement			–0.38
Adverbial Phrase: Time			–0.59

Notes.

- Variance explained: 60%.
- KMO Sampling adequacy: 0.65 (Test of sphericity $p < .001$, $\chi^2 = 192.3$, $df = 45$ $p < .001$).
- Loadings < ±0.38 are suppressed.

Each PC represents a linear combination of variables (i.e., elaborated syntactic frames) that reliably co-occur in the corpus. The value for any variable is its weight in a given PC. For instance, the syntactic frame *verb phrase* was prominent in the second PC, reliably elaborated and occurring where there were elaborated *verb phrases with a clitic*. A variable's corresponding value (e.g., *verb phrase* = 0.87) represents its weight (i.e., loading) in the linear equation. In reducing the dataset by requiring a high common variance, we were able to establish minimum weights (i.e., load suppression levels) that are higher than normal for corpus analyses, which ultimately increases the reliability of the current analysis. The general rule of thumb in corpus research is ±0.30. This component matrix had nine variables at a suppression level greater than ±0.56, and one at −0.38. No one PC correlated with another, such that no *macro elaboration pattern* constitutes a sub-pattern of another.

The first and most prominent monolingual *macro elaboration pattern* (i.e., PC1) entails a combination of relative clauses, nominal clauses, prepositional phrases and noun phrases. Essentially, the linear equation (Clause: Relative × 0.92) + (Prepositional Phrase × 0.87) + (Clause: Nominal × 0.81) + (Noun Phrase × 0.70) reflects the observation that, in conversational interactions, monolinguals concentrate syntactic elaboration in subordinate clauses and NPs.

The second monolingual *macro elaboration pattern* (i.e., PC2) involves verb phrases with and without one or more clitic pronouns. Effectively, the linear equation (Verb Phrase w/Clitic × 0.90) + (Verb Phrase × 0.87) reflects the observation that, in conversational interactions, when monolinguals elaborate a verb phrase, they use a finite and one to two non-finite forms, or they couple a verb with one or more clitic pronouns.

The third and least prominent monolingual *macro elaboration pattern* (i.e., PC3) reveals that monolinguals also elaborate syntactic frames serving a prototypical modifier (e.g., adjective, adverb) role. The opposing mathematical signs of the weights of the linear equation (Adverbial Phrase: Location × 0.64) + (Adjectival Phrase × 0.56) + (Adverbial Phrase: Pragmatic agreement × −0.38) + (Adverbial Phrase: Time × −0.59) suggest that monolinguals concentrate elaboration in prototypical modifiers either (i) in adverbials of location and adjectival phrases, or (ii) in adverbials of pragmatic agreement and time.

Concerning the identification of clusters of HLLs differing in degree of structural elaboration, for each of the HLLs, we calculated three scores, one for each of the monolingual *macro elaboration patterns* identified in the PCA. For instance, an HLL who demonstrated a lot of elaboration where monolinguals concentrate elaboration might score 26.3 on the *subordination with NP's macro elaboration pattern* (i.e., PC1), a 6.1 on the *verb phrase's macro elaboration pattern* (i.e., PC2), and a 0.5 on the *modifier's macro elaboration pattern* (i.e., PC3). Another HLL participant who demonstrated little overall elaboration might score, respectively, 15.4, 2.4, and −1.2. As described above (see Section 3.4), the k-means analysis, which groups individuals based on the similarities of *these three scores*, might place the two participants into different clusters because their overall elaboration scores were mathematically different. To correct for positive skewness so as not to violate the assumption of normality, we transformed the dataset with a Log10 transformation. The k-means analysis utilized the sum-of-squares method to calculate a hierarchy of clusters, and we utilized the elbow method (i.e., similar to the PCA scree method) to determine the number of compact groups. The analysis accounted for a large amount of the variation (77.5%), identifying three groups of HLLs.

Figure 1 compares the clusters based on the average z-scores of each of the *macro elaboration patterns*, providing a simplified visual of how the monolingual elaboration patterns distinguished the three groups of HLLs. Half of the participants fell into cluster 1 ($n = 30$), representing those that exhibited an average amount of structural elaboration across the entire HLL sample. Another quarter of the sample demonstrated below-average structural elaboration (cluster 2, $n = 17$), and another quarter demonstrated above-average elaboration (cluster 3, $n = 18$). Analyses of variance (ANOVAs) indicated that the three clusters differed significantly in terms of their different *subordination with NP's elaboration patterns*, $F(1, 63) = 239.8$, $p < 0.001$, $\eta^2 = 0.79$, and in terms of their *verb phrase's elaboration patterns*, $F(1, 63) = 10.49$, $p = 0.002$, $\eta^2 = 0.14$. All told, the k-means analysis suggests that these third-year, university-level HLLs exhibited a range of structural elaboration behaviors.

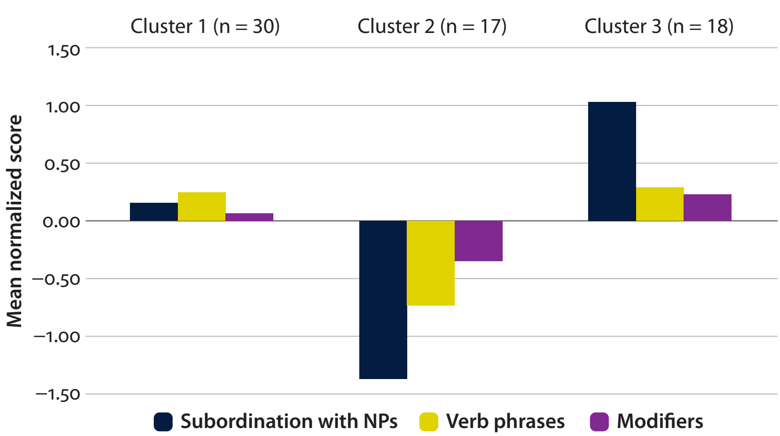

Figure 1. HLL mean z-scores per macro elaboration pattern by k-means cluster assignment

It is also interesting to note that a comparison of the three clusters in terms of their respective overall syntactic and lexical complexity (see Section 3.2) revealed that the clusters differed only in terms of *clauses per turn*, $F(2, 62) = 3.41$, $p = 0.040$, $\eta^2 = 0.10$. Post hoc tests showed that the difference was due to the fact that the below-average structural-elaboration cluster used significantly fewer clauses per turn than either the average or the above-average cluster. It may be that there is a cognitive threshold for some HLLs where processing complex syntax taxes attentional resources and working memory, leading to the production of fewer overall constituents and less elaboration within any given constituent.

To better understand the extent to which cognitive factors might explain the heterogeneous elaboration patterns we observed amongst the HLLs, we sought to ascertain whether the syntactic frames that most distinguish the three groups constitute core phrase structures or whether they entail inherently complex (i.e., hierarchical) syntax. We reasoned that, if the latter were the case, we could argue that cognitive factors were interacting with these HLLs' production of structural elaboration since the processing of hierarchical syntax can stress the cognitive resources of any speaker of a language, since using such syntax in spontaneous production requires a high degree of proceduralization (cf. DeKeyser, 2016; Ferreira, 1991; Housen & Kuiken, 2009). Specifically, we sought to determine which of the syntactic frame types ascribed to the *subordination with NP's elaboration pattern* (PC1) and the *verb phrase's elaboration pattern* (PC2) most distinguished between the three HLL groups. To that end, we employed a discriminant analysis (cf. Tabachnick & Fidell, 2012) where the independent variables were, for each HLL, the (transformed) average number of non-nuclear node counts of the variables included in PC1 and PC2 (see Table 3.) The grouping variable for each HLL was cluster assignment. The analysis identified 2 discriminant functions, Wilks' lambda = 0.07, χ^2 $(12, N = 65) = 157.5$, $p < .001$, correctly classifying 90.8% of the original grouped cases. A single function accounted for fully 99.7% of the observable variance, and so we focus on its results. The HLLs' elaboration in *relative clauses, nominal clauses*, and *verb phrases with a clitic* distinguished significantly between the three clusters.

Figure 2 provides a graphical representation of the three clusters' elaboration with the syntactic frame types that most discriminated between the HLLs, along with the original monolingual elaboration scores. Figure 3 provides the raw counts of each syntactic frame for the HLLs. There are two important observations. First, the below-average HLL cluster elaborated much less than either of the other HLL clusters or the monolingual comparison in verb phrases with clitics, $F(3, 126) = 13.71$, $p < .001$, $\eta^2 = 0.25$. Additionally, the below-average group produced few verb phrases with clitics. The HLL corpus samples in (1) and (2) depict the difference in elaboration between the below-average and above-average clusters.

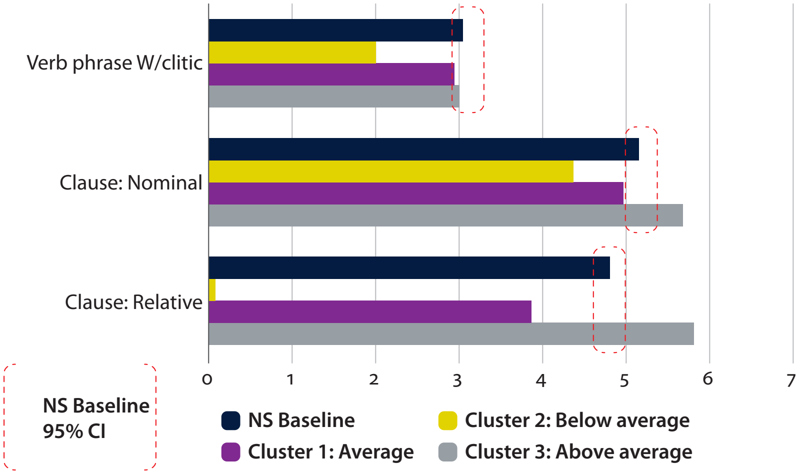

Figure 2. Mean elaboration scores for discriminating syntactic frame types by HLL cluster and monolingual

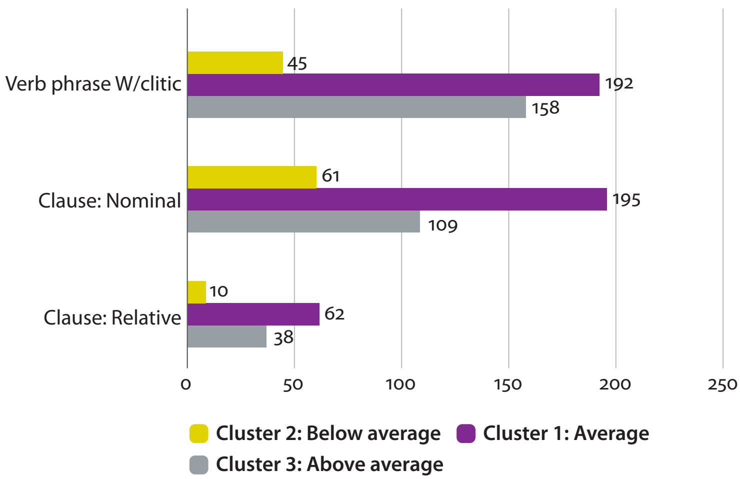

Figure 3. Raw counts for discriminating syntactic frame types by HLL cluster

The below-average examples have a single clitic pronoun and a single finite verb, whereas the above-average examples contain either an additional non-finite verb (e.g., a participle) or a direct object NP.

(1) Below-average elaboration cluster: Verb phrase with a clitic.
   a. Sí, [SV [SN lo] [V se]].
   b. no [SV [SN me] [V digas]]
   c. porque [SV [SN me] [V dijieron]] que [SV [SN se] [V fue]]

(2) Above-average elaboration cluster: Verb phrase with a clitic.
  a. Tito le mostró una moneda que su abuelo [SV [SN le] [V avía] [V regalado]]
  b. ella [SV [V ha] [V estado] [V buscando] [SN lo]]
  c. ella [SV [SN le] [V pidió] [SN dinero]]

Second, both the average HLL elaboration cluster and especially the below-average cluster elaborated relative clauses much less than either the above-average HLL cluster or the monolingual comparison, $F(3, 126) = 158.00$, $p < .001$, $\eta^2 = 0.79$. The corpus samples in (3) and (4) illustrate the difference in relative-clause elaboration between the below-average and above-average clusters. The below-average examples have a single finite verb, two of which are modified by an adverb. The above-average examples contain a direct object NP, an adjunct in the form of a prepositional phrase, and/or a clitic pronoun.

(3) Below-average elaboration cluster: Relativization.
  a. solamente robaron paginas de su diario y [NP el mapa] [[C' que] [VP [V tenía] [Adv allí]]]
  b. es [NP un viejo] [[C' que] [VP [V toma] [Adv mucho]]]
  c. Juan era [NP la última persona] [[C' que] [VP salió]]

(4) Above-average elaboration cluster: Relativization.
  a. Juan fue [NP el señor] [[C' que] [VP [V tocó] [NP música]] [PP [P en] [NP la fiesta]]]
  b. [NP los pasos] [[C' que] [VP [NP se] [V vieron] [PP [Adv afuera] [P de] [NP la fiesta]]]] se miraban que la pesona entró y salió
  c. estaba caminando por [NP el camino] [[C' que] [VP [NP la] [V lleva] [PP [P a] [NP su casa]]]]

5. Discussion and conclusions

Concerning the first research question as to the types of structural elaboration exhibited by advanced HLLs in spontaneous and meaningful production, the answer requires a consideration of two contrasting perspectives. On the one hand, the HLLs in this study were fairly homogeneous in terms of their general Spanish linguistic abilities, considering the syntactic complexity, the breadth of vocabulary, and the lexical diversity that they produced. (See Section 3.3). Additionally, considering the differences in the four linguistic complexity scores (see Table 1), it is evident that the HLLs demonstrated only slightly less overall linguistic complexity than what was calculated in the monolingual comparison. On the other hand, when we assess HLL production with monolingual models of structural elaboration exhibited within core phrase structures (e.g., NP, PP) or subordinate clauses, we have evidence that these bilinguals vary greatly amongst each other. Some HLLs (i.e., approximately a quarter in the present study) tend to produce few clauses per turn and no more than one or two constituents per syntactic frame. Others (i.e., again, approximately a quarter in the present study) tend to regularly elaborate core phrase structure and subordinate clauses, at levels that are similar to monolinguals (see Figure 2.)

In online Spanish processing tasks where research considers factors such as moment-by-moment processing times and the order in which constituents are processed, HLLs frequently exhibit biases and strategies that parallel monolingual behaviors and that differ from those of L2 learners (cf. Jegerski, 2017). For example, Montrul, Davidson, de la Fuente, and Foote (2014) report that Spanish monolinguals' and HLLs' online processing of grammatical and ungrammatical NPs (e.g., **el/la quinta calle* 'the fifth street') in a production task varies significantly, presumably because ungrammatical segments are detected somehow as erroneous; L2 learners, however, process grammatical and ungrammatical NPs as if there were no differences. Keating et al. (2016) report that HLLs and monolinguals exhibit similar online processing profiles when processing overt subject pronouns (Keating et al., 2016). Still, Keating et al. (2016) also found "considerable variability" (p. 46) amongst the HLLs' interpretation of subject pronouns. We submit that the results of the previous and the present studies suggest that (i) a significant proportion of HLLs process Spanish with the same biases and strategies that monolinguals use but that (ii) an important sub-portion of the population present processing profiles that differ from those of monolinguals. Research needs to continue to elucidate the cognitive similarities and differences so that language instruction can optimally serve these students.

Regarding the second research question as to the probable cognitive explanations for the types of structural elaboration exhibited by advanced HLLs, cognitive processing limitations likely account for the lack of syntactic elaboration observed in a small but statistically significant sub-portion of the HLLs studied here. In two syntactic frames, a quarter of the sample generated little elaboration in meaningful, spontaneous production, when compared to monolingual production: *verb phrases with clitics* and *relative clauses*. Both structures entail considerable structural complexity. The verb phrase requires encoding verbal inflections, and if it includes clitics, pronouns must be linked to referents in the discourse or the situation. Relative clauses are structurally and conceptually complex since an antecedent's reference must be disambiguated across clauses (e.g., *Mi tío vio a la hermana de la mujer* ***que*** *vivía calle abajo*). The processing of the aforementioned linguistic properties of *verb phrases with clitics* and *relative clauses* is likely to tax attentional resources and working memory in input or output. Both can entail processing long-distance references within sentences and across a discourse/conversation.

Additionally, the efficient processing of syntactic or morphological complexity, such as subordination or verbal inflections, requires the automatic retrieval of procedural knowledge (DeKeyser, 2016). Furthermore, as mentioned above, Jegerski (2018) recently notes that it is unclear whether some HLLs vary in their interpretation of relative-clause antecedents due to L1-L2 transfer effects or due to the cognitively taxing nature of the structure. Of course, Jegerski's (2018) conjecture applied only to input processing. However, while input processing and output processing differ in important ways, they also utilize similar cognitive resources (e.g., phonological memory, working memory).

We fully recognize the study's limitations, which future research must address. Although instant messaging is an increasingly popular mode of spontaneous, interactive communication, SCMC does not impose all of the cognitive pressures that face-to-face conversations do. Support for the findings will involve research on elaboration in oral interactions and psycholinguistic research involving productions. Additionally, while the monolingual oral conversational corpus provided a comparable point of reference, future comparisons entailing a monolingual instant-messaging corpus will yield more reliable insights.

It may be time for HLL teachers and curriculum designers to consider the cognitive processing factors interacting HLLs. Many instructional strategies employed in foreign-language instruction (e.g., Processing Instruction, Task-based Language Teaching) have been informed by research on cognitive processing. It may be time to develop robust research programs that study the interaction between cognitive factors and heritage language in the classroom setting in order to support HLLs in their educational goals.

References

Arroyo, D. C., & Yilmaz, Y. (2018). An open for replication study: The role of feedback timing in synchronous computer-mediated communication. *Language Learning*, 68(4), 942–972. https://doi.org/10.1111/lang.12300

Benmamoun, E., Montrul, S., & Polinsky, M. (2013). Defining an "ideal" heritage speaker: Theoretical and methodological challenges: Reply to peer commentaries. *Theoretical Linguistics*, 39(3–4), 259–294.

Biber, D., Davies, M., Jones, J., & Tracy-Ventura, N. (2006). Spoken and written register variation in Spanish: A multi-dimensional analysis. *Corpora*, 1(1), 1–37. https://doi.org/10.3366/cor.2006.1.1.1

Bird, S., Loper, E., & Klein, E. (2009). *Natural language processing with python*. New York, NY: O'Reilly Media.

Bolger, P. A., & Zapata, G. C. (2011). Psycholinguistic approaches to language processing in heritage speakers. *Heritage Language Journal*, 8(1), 1–29.

Bowles, M. (2011). Measuring implicit and explicit knowledge. What can heritage language learners contribute? *Studies in Second Language Acquisition*, 33(2), 247–271. https://doi.org/10.1017/S0272263110000756

Bruhn de Garavito, J. (2002). Verb raising in Spanish: A comparison of early and late bilinguals. In B. Skarabela, S. Fish, & A. Do (Eds.), *Proceedings of the 26th annual Boston University Conference on Language Development* (pp. 84–94). Somerville, MA: Cascadilla.

Bulté, B., & Housen, A. (2012). Defining and operationalizing L2 complexity. In A. Housen, F. Kuiken, & I. Vedder (Eds.), *Dimensions of L2 performance and proficiency: Complexity, accuracy and fluency in SLA* (pp. 21–46). Amsterdam: John Benjamins. https://doi.org/10.1075/lllt.32.02bul

Collentine, J., & Collentine, K. (In press). Insights into the cognition of mood selection in L2 learners of Spanish. In D. Pascual y Cabo, I. Elola, M. Tecedor, & B. Regan (Eds.), *Proceedings of the 2017 Hispanic Linguistics Symposium*. Amsterdam: John Benjamins.

Collentine, K. (2018). La complejidad lingüística en la comunicación mediada por computadora. In M. González-Lloret & M. Vinagre (Eds.), *Comunicación mediada por tecnologías: Aprendizaje y enseñanza de la lengua extranjera* (pp. 108–123). Sheffield: Equinox.

DeKeyser, R. (2016). Of moving targets and chameleons: Why the concept of difficulty is so hard to pin down. *Studies in Second Language Acquisition*, 38(2), 353–363. https://doi.org/10.1017/S0272263116000024

Ferreira, F. (1991). Effects of length and syntactic complexity on initiation times for prepared utterances. *Journal of Memory and Language*, 30(2), 210–233. https://doi.org/10.1016/0749-596X(91)90004-4

Housen, A., & Kuiken, F. (2009). Complexity, accuracy, and fluency in second language acquisition. *Applied Linguistics*, 30(4), 461–473. https://doi.org/10.1093/applin/amp048

Housen, A., & Simoens, H. (2016). Introduction: Cognitive perspectives on difficulty and complexity in L2 acquisition. *Studies in Second Language Acquisition*, 38(2), 163–175. https://doi.org/10.1017/S0272263116000176

Jegerski, J. (2017). Psycholinguistic perspectives on heritage Spanish. In K. Potowski & J. Muñoz-Basols (Eds.), *The Routledge handbook of Spanish as a heritage language* (pp. 221–234). New York, NY: Routledge.

Jegerski, J. (2018). Sentence processing in Spanish as a heritage language: A self-paced reading study of relative clause attachment. *Language Learning*, 68(3), 598–634. https://doi.org/10.1111/lang.12289

Keating, G. D., VanPatten, B., & Jegerski, J. (2016). Online processing of subject pronouns in monolingual and heritage bilingual speakers of Mexican Spanish. *Bilingualism: Language and Cognition*, 19(1), 36–49. https://doi.org/10.1017/S1366728914000418

Kroll, J., Dussias, P., Bice, K., & Perrotti, L. (2014). Bilingualism, mind, and brain. *Annual Review of Linguistics*, 1, 377–394. https://doi.org/10.1146/annurev-linguist-030514-124937

Meyer, A., Alday, P., Decuyper, C., & Knudsen, B. (2018). Working together: Contributions of corpus analyses and experimental psycholinguistics to understanding conversation. *Frontiers in Psychology*, 9, 525. https://doi.org/10.3389/fpsyg.2018.00525

Michalke, M. (2018). koRpus: An R package for text analysis (Version 0.11–5). Retrieved from <https://reaktanz.de/?c=hacking&s=koRpus> (13 March, 2020).

Montrul, S. (2006). On the bilingual competence of Spanish heritage speakers: Syntax, lexical-semantics and processing. *International Journal of Bilingualism*, 10(1), 37–69. https://doi.org/10.1177/13670069060100010301

Montrul, S., & Bowles, M. (2009). Back to basics: Incomplete knowledge of differential object marking in Spanish heritage speakers. *Bilingualism: Language and Cognition*, 12(3), 363–383. https://doi.org/10.1017/S1366728909990071

Montrul, S., Davidson, J., de la Fuente, I., & Foote, R. (2014). Early language experience facilitates gender agreement processing in Spanish heritage speakers. *Bilingualism: Language and Cognition*, 17(1), 118–138. https://doi.org/10.1017/S1366728913000114

Montrul, S., Foote, R., & Perpin, S. (2008). Gender agreement in adult second language learners and Spanish heritage speakers: The effects of age and context of acquisition. *Language Learning*, 58(3), 503–553. https://doi.org/10.1111/j.1467-9922.2008.00449.x

Montrul, S., & Polinsky, M. (2011). Why not heritage speakers? *Linguistic Approaches to Bilingualism*, 1(1), 58–62. https://doi.org/10.1075/lab.1.1.07mon

Norris, J. M., & Ortega, L. (2009). Towards an organic approach to investigating CAF in instructed SLA: The case of complexity. *Applied Linguistics*, 30(4), 555–578. https://doi.org/10.1093/applin/amp044

Pascual y Cabo, D., & Gómez Soler, I. (2015). Preposition stranding in Spanish as a heritage language. *Heritage Language Journal*, 12(2), 186–209.

Reif, M., & Robinson, J. (2016). *Cognitive perspectives on bilingualism*. Berlin: De Gruyter. https://doi.org/10.1515/9781614514190

Sánchez Abchi, V., & De Mier, V. (2017). Syntactic complexity in narratives written by Spanish heritage speakers. *Vigo International Journal of Applied Linguistics*, 14(1), 125–148.

Scontras, G., Fuchs, Z., & Polinsky, M. (2015). Heritage language and linguistic theory. *Frontiers in Psychology*, 6, 1545. https://doi.org/10.3389/fpsyg.2015.01545

Sorace, A. (2011). Pinning down the concept of 'interface" in bilingualism. *Linguistic Approaches to Bilingualism*, 1(1), 1–33. https://doi.org/10.1075/lab.1.1.01sor

Stockwell, G. (2010). Effects of multimodality in computer-mediated communication tasks. In M. Thomas & H. Reinders (Eds.), *Task-based language learning and teaching with technology* (pp. 83–104). London: Continuum.

Tabachnick, B. G., & Fidell, L. S. (2012). *Using multivariate statistics*. Boston, MA: Pearson Education.