Heritage speaker and late bilingual L2 relative clause processing and language dominance effects

by

LeeAnn Stover Stevens

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Professor Gita Martohardjono

Date

Thesis Advisor

Professor Gita Martohardjono

Date

Executive Officer

The City University of New York

Abstract

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Advisor: Professor Gita Martohardjono

Traditionally, heritage speakers are recognized as a heterogeneous group whose skills in their heritage language are unlike those of monolinguals or L2 learners of that language. Indeed, much evidence confirms the cognitive and linguistic uniqueness of this population. However, highly proficient heritage speakers may pattern more similarly to another bilingual population than typically assumed: first-generation late bilinguals.

The present study examines group-level processing differences between Spanish heritage speakers and Spanish-English late bilinguals in English, the second-learned and current societal majority language of these populations. Dominance is also analyzed as a possible effect of group processing differences, since traditionally and definitionally it is a main factor in distinguishing these two bilingual groups.

The robustly-attested processing asymmetry between subject-relative clauses and object-relative clauses is examined utilizing eye-tracking in the visual world paradigm to analyze bilingual processing in this study. Processing is measured through gaze fixation, and language dominance is operationalized using a novel relative fluency (RF) index. Results support that (1) These two populations do not pattern differently from each other in their accuracy, response time, or target fixation proportions throughout either RC condition (2) Both groups are only showing mild evidence for a subject/object processing asymmetry, and (3) There are group differences in language dominance, but dominance has no main effect on gaze fixation.

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Chapter 1

Introduction

The study of heritage speakers, bilinguals whose first-learned, home language is a societal minority language that they acquire in informal settings but who live, work, and are educated in the societal dominant language, has garnered much attention in the last two decades. This interest is for both theoretical and practical reasons, as this type of bilingual is becoming ever more prominent in our current global context of migration and geopolitical change. As such, studying and understanding heritage speakers is crucial to fields such as theoretical linguistics, applied linguistics and education, language acquisition, and psycholinguistics. The study of heritage language processing is still in its infancy, and much remains to be learned from analyzing this unique and heterogenous population which could be beneficial to the broader understanding of bilingualism as a whole.

Due to their linguistic background, heritage speakers (HSs) tend to be definitionally dominant in their second-learned language. Studying their L1, the heritage language, can shed light on theoretical topics such as language attrition and grammatical restructuring. Studying their L2, on the other hand, has been left mostly untouched in the field of psycholinguistics but can also be beneficial. Their unique experience with their first and second languages has made it difficult to compare HSs to other groups of speakers. Early in the field of heritage linguistics, HSs were almost exclusively compared to monolinguals or L2 learners of the heritage language (HL). However, the *baseline* language for HLs is well-acknowledged to be that of the first-generation immigrants who provide the majority of input for HSs (e.g., Polinsky, 2018). As such, in recent years experimental studies of HSs have begun to directly test these two populations for group comparisons (e.g., Montrul and Sánchez-Walker, 2013).

In a previous study in the Second Language Acquisition Lab at The Graduate Center, CUNY, an eye-tracking study using the Visual World Paradigm measured gaze fixation patterns to compare highly proficient bilingual HS L1 Spanish processing with that of first generation immigrant late bilinguals (LBs), the time-apparent parents of this population who were raised in a Spanish-speaking country or region and arrived to the anglophone US in adulthood who now live and work in an L2-dominant society. Unexpected results were found, as the LB group demonstrated the processing phenomenon of interest and the HSs did not. However, accuracy for both groups was comparably high and the HSs were not indicating reduced comprehension or slower processing overall. Rather, the groups differed on a processing level and how they converged on the correct answers.

The overarching goal of this paper is to explore whether LBs and HSs are truly conceptually and cognitively distinct populations. Qualitatively, reviews of how the literature has treated these populations will be briefly discussed. Quantitatively, this study explores processing patterns of Spanish-English HSs and LBs to examine group differences and see if these participants exhibit the same patterns in their L2, English, which is the dominant language of the larger society they live in. Crucially, while English is the second-learned language of all of these participants, HSs are more likely to be dominant in English since they were raised in an environment where their L2 was the societal majority language. If group differences are found opposite to the Spanish study, it is possible that language dominance is driving bilingual processing differences. Thus, a secondary goal is to test whether language dominance can explain the processing patterns found in the first experiment.

Specifically, I ask two main research questions:

i) Do online eye movement patterns reflect a subject/object asymmetry in relative clause processing differently for heritage speaker and late bilingual adults in English, their second learned language?

ii) Can language dominance explain processing differences in highly proficient heritage speakers and late bilinguals?

This thesis diverges from typical HS studies in two notable ways. First, I focus my attention on speakers with highly productive competence in their heritage language. I do not claim that these results or observations would extend to speakers with less exposure to or proficiency in their heritage language, but there are a wealth of HS studies which do make claims specifically for this more popular distinction of HSs in the US (for a review on these speakers, see Montrul, 2016). Second, the processing experiment conducted in this paper is in the L2, meaning that these speakers are not being tested in their heritage language but rather the societal majority language. To my knowledge, no previous real-time processing experiment has investigated the non-heritage language of this population.

The paper will be structured as follows: First, I will introduce heritage speakers as a population and briefly mention how they have been studied as a group. I will conceptually compare this group to late bilinguals, who acquire an L2 later in life. Next, I will describe the structure of interest for this eye-tracking study, relative clauses, along with theories for a robustly noted processing asymmetry attested in these structures. I will also present results from the previous eye-tracking study that analyzed relative clause processing among Spanish-English HSs and LBs, which motivated the current research. Chapter 4 introduces and discusses the current eye-tracking study, which examines L2 processing among highly proficient HSs and LBs to investigate if they demonstrate the processing asymmetry or show any group differences in their gaze fixation patterns. Chapter 5 will reanalyze this data through a lens of language dominance with a novel objectively-measured index that accounts for the gradient, relative nature of dominance. Finally, I will conclude with a general discussion and a petition for further examination of HS language processing and dominance.

Chapter 2

Comparing bilingual groups

Heritage Speakers (HSs) are childhood bilinguals of a heritage language (HL) and a societal majority language learned either sequentially or simultaneously (Rothman, 2009). The HL is learned naturalistically as a first language and is spoken in the home, and typically these speakers experience no formal schooling in their HL. The majority language, on the other hand, is the language that these speakers live, work, and are educated in. HSs comprise a very heterogeneous population, and can range from passive listeners to fully balanced bilinguals. This group is of interest to bilingual researchers because their language profile differs substantially from other types of bilinguals and L2 learners. Where most other bilingual types tend to be more proficient in their L1 due to more exposure and use, HSs follow the opposite trend and tend to be L2-dominant.

HS literature has documented behavioral outcomes in the L1 of HSs. As compared to other native speakers and L2 learners, HSs have been shown to diverge in their production (e.g., Fenyvesi, 2005), comprehension (e.g., Polinsky, 2006), grammatical intuition (e.g., Montrul and Bowles, 2009), lexical diversity (e.g., Hulsen, 2000), and identity (e.g., Zhang and Slaughter-Defoe, 2009). HS literature has noted that the L1 acquisition of HSs may be incomplete (Benmamoun et al., 2010; Scontras et al., 2015) or may undergo attrition due to disuse and lack of sustained exposure (Montrul, 2004; Polinsky, 2011). This bilingual population is also noted for its linguistic insecurity (Klein and Martohardjono, 2009). While a variety of studies exist that explore HS behavioral outcomes, virtually nothing is known about their psycholinguistic processing (as commented in Bolger and Zapata, 2011).

Heritage speaker competence, like all bilinguals, falls on a continuum. Some HL research has adopted the model of language mastery proposed by Haugen (1987), where acrolectal speakers are closest to the baseline in their production and understanding of the language, mesolectal speakers fall somewhere in the middle, and basilectal speakers show significant divergence. Many studies of HS focus on the middle and most divergent populations, as they are the most common in the Western world. However, some HS populations in the US do fall on the acrolectal scale. For example, New York City Spanish has been argued to comprise its own speech community as it is so vibrant in many social domains (Otheguy et al., 2007). This community has a strong sense of linguistic identity to the societal minority language, and as such its HSs tend to be more productive and proficient in the HL due to increased, sustained input and exposure.

In trying to understanding whether heritage language is different than the input language, it is important to compare the HL to to language of first-generation immigrants who provide the input to these HSs. As stated in the introduction, this is a much more appropriate comparison than a monolingual baseline or even a bilingual from the homeland (if there is one). Adult speakers of the HL in the homeland are exposed to innovations of their generation in ways that are mostly inaccessible to HSs in diaspora, so it is uninformative to compare these two populations (Polinsky, 2018). However, finding willing first-generation immigrant participants (in this study called LBs) can be a daunting task in certain settings, which has led to a shortage of direct processing comparisons between these two groups up until this point.

Several studies show support that the linguistic abilities of the first generation are 'superior' to those of the second generation (HSs) in morphosyntax, semantics, pragmatics, and the lexicon (e.g., Hulsen, 2000; Silva-Corvalán, 1994). Other studies, on the other hand (e.g., Nagy et al., 2004) found no differences transgenerationally. One major study that compares these two groups directly is Montrul and Sánchez-Walker (2013), who tested Spanish differential object marking (DOM). They found that adult LB accuracy levels were comparable to the adult HSs, and that DOM omission rates showed similarity to young adult HSs. However, a follow-up study with more languages (Hindi and Romanian: Montrul et al., 2015) showed that no first-generation immigrants in the Hindi and Romanian groups omitted a single DOM. An analysis of the sociolinguistic profiles of these two groups (Madsen, 2018) showed that Spanish-English HSs and LBs differ in their language use, exposure, and identity but do not diverge in their language ability. Finally, psycholinguistic studies of HSs and LBs using pupillometry and event-related potentials show differential processing and sensitivity between the groups (e.g., Madsen et al., 2019; Martohardjono et al., 2017; Lowry et al., 2019).

Though many studies do not test HSs and LBs directly, some L2 and LB findings are relevant to HS research and group comparisons. For example, like with HSs, attrition and restructuring in the L1 of LB speakers has been documented (e.g., Gürel, 2004; Bylund, 2009; Schmid, 2010). Additionally, L2 processing has been shown to be modulated by proficiency (e.g., Rossi et al., 2006; Tokowicz and MacWhinney, 2005) and age of onset (e.g., Higby et al., 2013). However, HSs require further considerations of lifetime exposure, contexts of use, and language dominance (Montrul, 2016). Additionally, on a comparison of LBs and highly proficient HSs using only proficiency and age of onset, the L1 processing of both groups would hypothetically be the exact same as this framework assumes little variation in the L1, and not much could be said at all about how HS L2 processing tends to be so native-like. Thus, it is important to consider these use and language dominance differences in both groups when analyzing group-level processing differences.

While these two bilingual groups have somewhat different backgrounds, learned their L2 at different ages, and show cognitive and behavioral differences, they also share important similarities: L1 attrition has been found in both groups, both groups are sensitive to linguistic phenomena in their L1, and higher proficiency leads to more native-like processing. The current linguistic environment and input is the same for both groups, as they live and work in an L2-dominant society and their use of the HL comes from each other. These considerations are valuable when studying and comparing these two bilingual groups.

Chapter 3

Relative clause processing asymmetry

To appropriately study the processing of these two bilingual populations, a linguistic phenomenon that is 1) not susceptible to cross-linguistic influence or attrition and 2) robust and well-documented is needed. Given these constraints, the subject-object relative clause processing asymmetry is an ideal candidate. Relative clauses (RCs) are structurally and syntactically similar in English and Spanish, so transfer effects would not play a role between a Spanish-English bilingual's dominant and non-dominant languages. RCs are also early-acquired and argued to be cross-linguistically universal (Comrie and Fernández, 2012), so they are likely not susceptible to attrition. Additionally, this asymmetry is a well-established phenomenon across a wide variety of languages and methodologies.

A relative clause, a subordinate clause embedded within a nominal phrase, is an example of a long-distance dependency consisting of a nominal head (which is modified by the RC) and a relativized complementizer phrase (the dependent element). In both Spanish and English, the nominal head is associated with an empty element, or gap position, within the subordinate clause. RCs vary in whether the modified noun head is associated with a gap in the subject position or the object position of the subordinate clause. The difference between subject-gap relative clauses and object-gap relative clauses is a major emphasis in both first and second language acquisition literature on RCs. In a subject-gap relative, such as (1) from Gass (1979) below, the noun phrase is the subject of both the matrix clause and the subordinate clause, so the gap appears in the subject position of the RC. An object-gap relative, such as (2), has a noun phrase which is the subject of the main clause but the object of the subordinate clause. This leaves the empty element or gap in the object position of the RC.

Subject-gap relative

(1) The girl who ______was crying ran home.

Object-gap relative

(2) The girl that I saw ______ran home.

In English, a relative clause is typically marked with a complementizer *that* or *who*. However, this complementizer is optional in object-gap relative clauses (Sánchez-Walker and Montrul, 2016). For example, (2) could also be expressed as 'The girl I saw ran home'. Additionally, word order in English is almost always fixed in both matrix and subordinate clauses as subject-verb-object. This leaves little room for structural changes in these clauses apart from an occasionally optional complementizer.

Embeddedness, the position of the subordinate clause as modifying the subject or object of the matrix sentence, is another factor in RCs. In a subject-embedded relative, as in (3), the RC modifies the subject of the matrix sentence. In an object-embedded relative, as in (4), the RC modifies the object of the matrix clause.

Subject-embedded relative

(3) The doctor that ______examined the tourist argued with the nurse.

Object-embedded relative

(4) The nurse argued with the doctor that ______examined the tourist.

These two axes create a four-way distinction of relative clauses: subject-subject RCs which are subject-embedded with subject gaps, subject-object RCs which are subject embedded with object gaps, object-subject RCs which are object-embedded with subject gaps, and object-object RCs which are object-embedded with object gaps. These are illustrated in (5)-(8), taken from Gibson et al. (2005).

Subject-subject relative

(5) The reporter who ______attacked the senator on Tuesday ignored the president.

Subject-object relative

(6) The reporter who the senator attacked ______on Tuesday ignored the president.

Object-subject relative

(7) The president ignored the reporter who ______attacked the senator on Tuesday.

Object-object relative

(8) The president ignored the reporter who the senator attacked ______on Tuesday.

Spanish RCs are similar to English in structure, with two notable differences. First, complementizers are obligatory in marking RCs in Spanish (*que* or *quien* for head nouns which are human). Secondly, Spanish word order is less fixed than English. While Spanish is an SVO language, it allows for post-verbal subjects. In subordinate clauses, it is typical to use verb-subject word order (Gutiérrez-Bravo, 2003). However, in RCs differential object marking can be used to disambiguate alternate meanings due to a more flexible word order. The Spanish examples in (9)-(12), taken from Sánchez-Walker and Montrul (2016), demonstrate a very similar structure to the English examples in (5)-(8):

Subject-subject relative

(9) El hombre que ______lee el periódico toma cafe.

'The man that ______reads the newspaper drinks coffee.'

Subject-object relative

(10) El estudiante que Isabel adora ______trabaja en la biblioteca.

'The student (that) Isabel adores ______works in the library.'

Object-subject relative

(11) El policía llama al hombre que ______estacionó mal el auto.

'The policeman calls the man that parked the car in the wrong way.'

Object-object relative

(12) Juana mira el árbol que el jardinero poda ______.

'Juana looks at the tree that the gardener trims ______.'

While RCs do have a four-way distinction, for the sake of simplicity the rest of this paper will only consider subject-embedded clauses (subject-subject relatives and subject-object relatives). Now that the structure of RCs have been introduced in both English and Spanish, the processing asymmetry can be discussed. This phenomenon posits that, in languages like English and Spanish, subject-relative clauses (SRCs) incur less of a processing cost than object-relative clauses (ORCs). There are various syntactic, semantic, and psycholinguistic accounts to explain this asymmetry, a few of which be described now. However, it is outside the scope of this study to evaluate these sources. What is important for the sake of this paper is that evidence for this SRC/ORC processing asymmetry is robust, and that it is an appropriate linguistic phenomenon to study HS and LB populations.

3.1 Syntactic and semantic accounts

Various syntactic and semantic accounts exist involving the mismatch between the syntactic or thematic roles of the relativized noun phrase in ORCs. In syntactic explanations, there is a discrepancy in the roles of the head noun in object-gap structures because the extracted/modified noun from the matrix clause undergoes a role reversal and becomes the embedded object (Sheldon, 1974). The extracted agent becomes a patient in its trace, which in this case incurs a processing cost is incurred because the syntactic/thematic role of the noun phrase must be reversed. However, for subject-subject relative clauses the relativized noun is the subject-agent in both the matrix and embedded clauses. With no mismatch, the structure is easily interpreted. Additionally, the preference for subject-gap relative clauses can be modulated by extracted noun phrase animacy (Mak et al., 2002,0) and semantic plausibility (Mecklinger et al., 1995).

3.1.1 Relativized minimality

A popular syntactic theory to account for the SRC/ORC asymmetry comes from Rizzi's (1990, et seq.) Relativized Minimality. (see also: Friedmann et al., 2009; Grillo, 2009; Starke, 2001). According to this theory, "the local relation between an extracted element and its trace is disrupted when it crosses an intervening element whose morphosyntactic featural specification matches the specification of the elements it separates" (Villata et al., 2016, p. 1). That is, an intervening element that shares the same features as the extracted element and its gap will cause problems to the processing of the structure (also called non-canonical sentences). As summarized in Rizzi (2001), Relativized Minimality can be illustrated as follows:

(13) Y is in minimal configuration with with X iff there is no Z such that

(i) Z is the same structural type as X, and

(ii) Z intervenes between X and Y.

Rizzi further defines ‘same structural type’ as Spec licensed by features of the same class in (14):

(14) a. Argumental: person, gender, number, case

b. Quantificational: Wh-, Neg, measure, focus...

c. Modifiers: evaluative, epistemic, Neg, frequentative, celerative, measure, manner

d. Topic

This Featural Relativized Minimality avoids the excessive freedom of movement that the Minimal Link Condition (Chomsky, 1995) allows, and is also less restricted than the initial, simple A/A’ distinction from when Relativized Minimality was first formulated (Rizzi, 1990). This notion is frequently extended to relative clauses. Under Relativized Minimality, SRC structures would meet the requirements for minimal configuration and be easy to interpret, while an ORC structure has an intervening element. The embedded NP is the same structural type and feature that lies between the extracted NP and its gap position or trace, which causes greater difficulty in interpreting the sentence. This is said to cause more difficulty for children in acquiring ORCs, and more difficulty for adults in ORC accuracy.

3.2 Psycholinguistic accounts

While any processing account is by its nature at least partially grounded in psycholinguistics, some sources of the SRC/ORC asymmetry rely almost exclusively on psycholinguistic elements: namely, on working memory or the parser. Several studies cite working memory demands to account for the asymmetry, that there is a greater processing cost in ORCs because they are held in mind for longer than SRCs. The gap is closer to the base position in SRCs, whereas in an ORC the gap is much further which this account argues creates a greater working memory load while the relativized noun is stored and utilizing memory resources for a longer time (e.g., Frazier and Fodor, 1978; Gibson, 1998; Juffs and Rodríguez, 2014; MacWhinney and Pléh, 1988).

Another psycholinguistic account for the SRC preference is called the *active filler* processing strategy, which posits that the parser will try to fill potential gaps at the earliest point allowed by the grammar (e.g., Clifton and Frazier, 1989, et seq.). In Spanish and English RCs, this first potential gap is in the subject position of the embedded clause immediately after the relativizer (*that* or *who* in English, *que* or *quien* in Spanish). In SRCs, the first part would be correct and the relativized noun can be filled in the subject position. With ORCs, on the other hand, the first parse fails because the gap is filled by an embedded DP and a reanalysis is required. This reanalysis leads to increased processing time and cognitive effort. This account was adopted by the precursor study to the current experiment (Stern et al., 2019), which will now be detailed.

3.2.1 Stern et al., 2019

As mentioned in the introduction, a previous experiment from the Second Language Acquisition Lab at the Graduate Center, CUNY compared Spanish-English LBs to HSs in their processing of aurally presented SRCs and ORCs in their L1 (Spanish) using the Visual World Paradigm, which time-locks a visual scene with related auditory input while eye movements are measured. The Visual World Paradigm has been utilized to demonstrate predictive processing in bilinguals and L2 learners with measurement of gaze fixation as a proxy for mental attention. Based on Stern et al.'s (2019) analysis from this experiment, there are four main findings from the Spanish RC data:

1. In regions 2 and 3 (the RC region and the matrix predicate region, see Section 4.1.3 for reference), LBs showed the SRC/ORC asymmetry with significantly

higher proportions of fixations on the target image for SRCs than ORCs. HSs, on the other hand, did not demonstrate the expected asymmetry.

2. In the RC region, LBs had a significantly higher target fixation proportion than HSs on SRCs, demonstrating an early group-level SRC advantage of LBs over HSs.

3. In the matrix predicate region, LBs had a significantly lower target fixation proportion than HSs on ORCs, demonstrating a late group-level ORC disadvantage of LBs compared to HSs.

4. No group-level effects on accuracy or response time were observed. However, across group, participants were significantly less accurate on ORCs than SRCs and marginally slower to respond on ORCs than SRCs.

Stern and colleagues cited the active filler hypothesis to explain these findings. Essentially, we found that LB participants showed the expected SRC/ORC asymmetry in their gaze fixation patterns while HSs did not. This was predominantly driven by an early SRC advantage for the LB participants and a late ORC processing disadvantage, which can be explained by an active attempt to fill the gap as soon as possible and a processing cost when the parser fails and has to re-analyze. HSs, on the other hand, did not seem to rely on active prediction as they processed ORCs faster than the LBs because they did not have to re-analyze after an incorrect prediction. Accuracy levels across participants were high indicating full comprehension of the structures from both groups, so the difference must lie somewhere in the realm of processing.

Stern et al. (2019) attributed the different group-level processing patterns in the L1 to extended immersion in an L2 environment, which HSs have, while LB participants grew up with much less exposure to their L2. Exposure is only one component known to impact bilingual group processing differences, however, as proficiency and use can also play a substantial role. All of these components are part of the broader construct of language dominance, which could play a useful role in explaining these findings. This motivated the current study and directly led to Experiment 1, which will now be discussed.

Chapter 4

Experiment 1: L2 relative clause processing

Despite their comprehension of both RC structures and the high proficiency of both populations tested in Stern et al. (2019), LBs showed a SRC/ORC asymmetry in their L1 while HSs did not. In order to tease apart what may be motivating these group differences, the L2 of these speaker groups needs to be tested. In this case, a within-subject replication of the RC experiment discussed in Section 3.2.1 conducted in English allows a comparison of how these participants process the SRC and ORC structures in both of their languages. If HSs, who are definitionally dominant in English, show the asymmetry while LBs do not, it is possible that dominance could be driving group processing differences. If similar patterns emerge in English as they did in Spanish and LBs continue to show an asymmetry while HSs do not, it is possible instead that type of bilingualism is affecting processing. Experiment 1 hopes to shed some light on this and to explore the other language of these Spanish-English bilingual participants. Since the tested language, English, is the L2 of both of these groups, second language considerations must first be addressed.

The RC asymmetry has been present in the Second Language Acquisition (SLA) literature for quite some time, ever since Gass (1979) applied the noun phrase accessibility hierarchy of Keenan and Comrie (1977) to relative clause acquisition. Studies of this kind argue that bilingual children and L2 adult learners alike both show patterns of a SRC/ORC asymmetry in their acquisition, which is modulated by language proficiency and structural similarity to the L1 (for a review, see Gass and Lee, 2007). One study (Yip and Matthews, 2007) even argues that a bilingual child's dominant language influences the pattern of RC acquisition in their non-dominant language. Similarly, studies within the Visual World Paradigm have shown that bilingual children and L2 learners demonstrate active prediction and semantic and morphosyntactic processing with similar modulation by language proficiency and structural similarity (e.g., Brouwer et al., 2017; Dussias et al., 2013; Lew-Williams and Fernald, 2010). This has motivated proposals that L2 learners have a reduced ability to generate expectations (Grüter et al., 2014) in their predictive processing. Given this background, one might predict that a processing study would show that bilinguals demonstrate a SRC/ORC asymmetry, but possibly less robust compared to their L1 or to a monolingual of the second language itself.

Relative clauses have received much attention in the first language acquisition processing literature (see Kidd, 2011 for a review), but as of the writing of this thesis and to the knowledge of the author, only one study has looked at L2 relative clause real-time processing specifically (Juffs and Rodríguez, 2014). In this study, the authors did find effects of gap site in reading times of highly proficient English L2 learners (L1 Spanish) such that ORCs produced slower reading times than SRCs. They also found lower accuracy on ORCs than SRCs. With this evidence and the implications of SLA literature, it seems very plausible that both LB and HS speakers would reflect an RC asymmetry in their processing as shown through gaze fixation in an eye-tracking experiment despite the fact that English is their second-learned language. If this is indeed the case, any group differences in these gaze fixation patterns could then possibly be attributed to language dominance rather than comprehension or proficiency levels.

Experiment 1 directly tests the first research question of this thesis:

> i) Do online eye movement patterns reflect a subject/object asymmetry in relative clause processing differently for heritage speaker and late bilingual adults in English, their second learned language?

4.1 Methods

4.1.1 Participants

A subset of the participants from the Spanish relative clause experiment described in Section 3.2.1 (*n*= 18) were financially compensated to participate in this study. All participants are Spanish-English bilinguals residing in New York City at the time of testing who have normal or corrected-to-normal vision and hearing and did not take antihistamines on the day of the experiment. At least four months passed between participant completion of the previous experiment in Spanish and this current replicated study in English. Participants were screened for pre-determined inclusion criteria, including a self-rated proficiency of 3 or higher on a 5-point Likert scale in both English and Spanish so that all participants are fluent in both languages.

Participants completed a language background questionnaire, including a survey developed in our lab with commonly collected items pertaining to language history (based on Li et al., 2006), and additional items pertaining to demographics, language ability, and language exposure. With this information, participants were classified as either HS or LB based on criteria commonly used in heritage speaker studies (Benmamoun et al., 2013). Mean participant characteristics by group for five variables of interest are summarized in Table 4.1, along with p-values from independent samples t-tests which probe for significant group differences.

As expected, there are significant group differences in Age of Arrival (AoA) and length of US residency (LoR). There are no significant group differences in age or in self-ratings for either language.

	HS M(SD)	LB M(SD)	variance
n	9	9	
Age	28.22(9.55)	31.44(7.67)	p=0.44
AoA	3.44(3.57)	25.78(5.26)	p<.001
LoR	23.44(8.49)	5.67 (7.19)	p<.001
Spanish Self-rating	4.67(0.5)	4.94(0.17)	p=0.15
English Self-rating	5(0)	4.5(0.71)	p=0.06

Table 4.1: Participant demographics and variance

The HS group consists of participants who were either born in the anglophone US or moved to the US by age 8. LB individuals, on the other hand, were born in a Spanish-speaking region and moved to the anglophone US at the age of 17 or older. Both groups learned Spanish as their first language, were raised by Spanish-speaking caregivers, and spoke primarily Spanish in their home until at least age 10. Eight Spanish-speaking countries/regions are represented in this study: Colombia, Dominican Republic, Guatemala, Honduras, Mexico, Puerto Rico, Uruguay, and Venezuela.

4.1.2 Stimuli and task

This experiment consists of 40 aurally presented stimuli which are grammatical complex English sentences, with 10 items per condition and 20 control structure fillers. There are two experimental conditions based on relative clause type: subject relative clauses (SRC), as in (15), and object relative clauses (ORC), as in (16). All matrix and embedded verbs are transitive, all nouns are animals depicted anthropomorphically in the visual stimuli, and both conditions of relative clauses are subject-embedded.

(15) The rabbit, who ______hugs the dog, brushes the bear.

(16) The rabbit, who the dog hugs ______, brushes the bear.

Stimuli were recorded in a sound-proof booth by a female L1 American English speaker using SoundForge as natural running speech with neutral prosody and sampled at 44.1kHz. All stimuli were normalized, amplified to an average loudness of -26.00 dB, the noise filtered out using Audacity 2.0.3 (Audacity Team, 2014), then exported as WAV files.

As audio stimuli were presented, participants saw an array of three images which consist of a target image and two distractors. Figure 4.1 illustrates an example set of images, which is the corresponding visual display for (15) above.

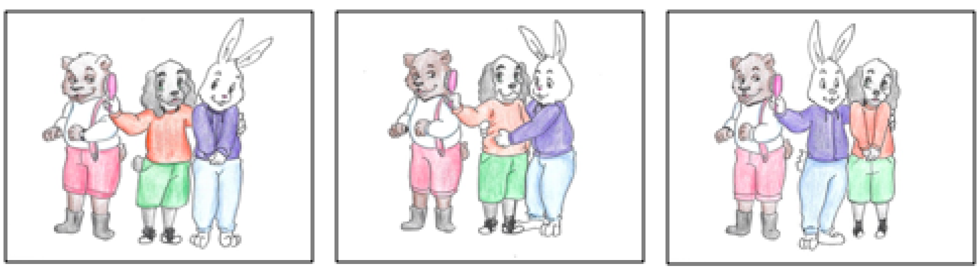

Figure 4.1: Sample visual display during experimental trial

Participants completed a picture-selection task. Stimuli were presented aurally over external speakers with a concurrent visual display presented on a computer screen using E-Prime 2.0 (Schneider et al., 2002). Each trial began with a black cross fixation marker appearing on the screen, which the participant clicked in order to see the images. After a familiarization period, the participant clicked again to hear the auditory stimulus. The participant then used a mouse click to select the image that best matched the aurally presented sentence. Gaze fixations were recorded throughout each pseudorandomized trial at 60 Hz using a Tobii TX300 eye-tracker. Additionally, trial accuracy and response time were recorded. Two participants were excluded from the gaze data results, as their cleaned data showed less than 30% average total fixation on the target image.

4.1.3 Temporal regions

Following the model of Stern et al. (2019) which is based on previous eye-tracking reading studies of the relative clause processing asymmetry (e.g., Traxler et al., 2002), the gaze data is divided into four temporal regions as shown in Figure 4.2.

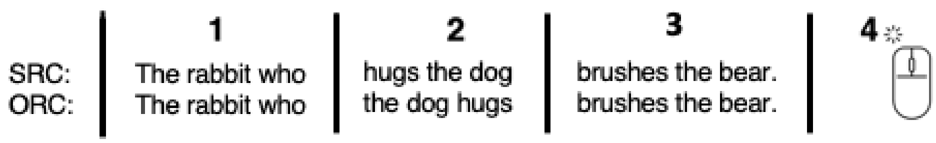

Figure 4.2: Division of audio stimuli into temporal regions

Region 1 begins with the onset of the spoken sentence and ends at the onset of the first word after the relativizer *who*. Region 1 is equivalent in the SRC and ORC conditions, and during this region the participant receives no information that would allow them to eliminate any of the distractor images as possible correct answers. The version of this experiment in Spanish found null results in this region, and therefore it will not be analyzed in the current study.

Region 2 extends from the onset of the word that follows the relativizer *who* through the offset of the relative clause. In the SRC condition, this region begins with the subordinate verb. For ORCs, this onset is the determiner that begins the embedded DP. The information provided in this region, if properly comprehended, allows for the elimination of one distractor image. Stern et al. (2019) found an SRC/ORC asymmetry for LBs in Spanish in this region such that LB (but not HS) participants have significantly higher target fixation proportions for SRCs than ORCs. Thus, if dominance is a determining factor, in this experiment I hypothesize that the HSs, who are English dominant, will demonstrate the processing asymmetry in this region while the LBs will not.

Region 3 extends from the onset of the matrix verb to the offset of the sentence, which is equivalent in both RC conditions. A successful comprehension of the information in this region allows a participant to converge on the target image. LBs (but not HSs) also showed an asymmetry in Region 3 such that ORCs had significantly lower target fixations than SRCs. To follow the hypothesis that language dominance is driving the asymmetry, I expect to find that the HSs will have significantly different target fixation proportions in the SRC and ORC conditions in this region.

Finally, Region 4 consists of the temporal region from the offset of the sentence through the time that the participant clicks on the correct answer. Similar to Region 1, no significant findings were yielded from this region in the previous study and therefore will not be discussed in detail in the current analysis.

4.2 Results

4.2.1 Data analysis

To analyze the data, data were fit with a generalized linear mixed effects model for the accuracy data and linear mixed effects models for the response time and gaze data. Models included relative clause type and bilingual group as fixed effects, with by-participant and by-item random slopes. The marginal means and their 95% confidence intervals were explored to determine significance of the within group differences between relative clause type, as well as independent samples t-tests where appropriate to compare groups during a single condition.

4.2.2 Behavioral results

	Estimate	Std. Error	z value	Pr(> $\|z\|$)	
(Intercept)	5.58	1.41	3.96	<0.001	***
ConditionORC	-1.40	0.58	-2.40	0.02	*

Table 4.2: Effect of RC type on accuracy

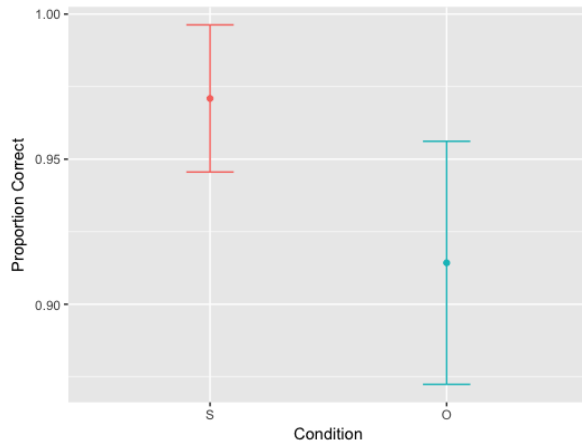

Figure 4.3: Overall participant average accuracy

A generalized model with a dependent variable of accuracy proportion for all participants reveals a main effect of condition such that ORC trials are less likely to be accurate than SRCs. Overall, participants show a SRC/ORC asymmetry in their accuracy. Additionally, there is a significant group difference in the ORC condition according to an independent samples t-test, $t(117) = 3.21, p < .01$. However, a model that includes both condition and bilingual group as main effects shows no main effect of either RC type or group (as seen in Table 4.3). Figure 4.4 shows means and confidence intervals for each group by condition, calculated both as proportion correct and in log odds of proportion correct.

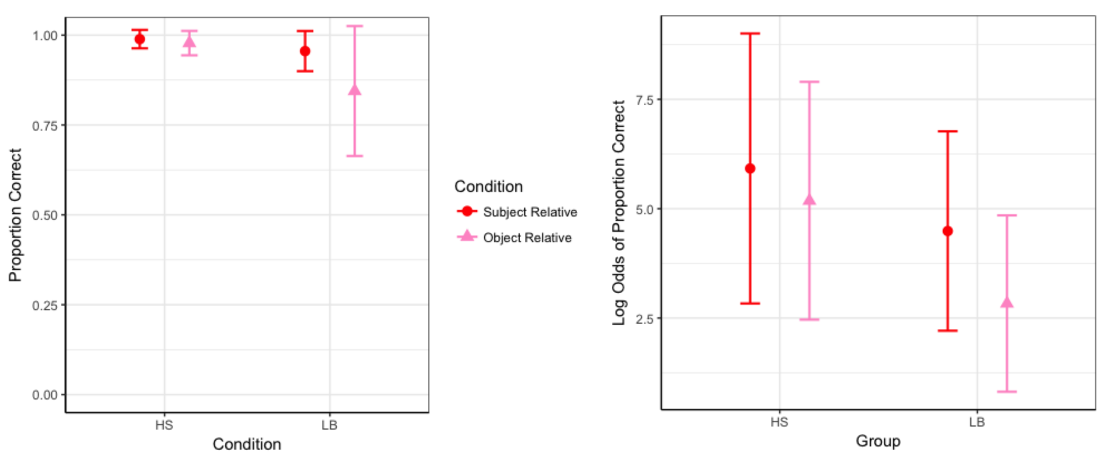

Figure 4.4: Participant average accuracy by group

	Estimate	Std. Error	z value	Pr(> |z|)	
(Intercept)	5.92	1.58	3.76	<0.001	***
GroupLB	-1.43	1.63	-0.88	0.38	
ConditionORC	-0.74	1.26	-0.59	0.56	
GroupLB:ORC	-0.92	1.41	-0.65	0.52	

Table 4.3: Effects of RC type and group on accuracy

Log-transformed response time (RT) across groups for accurate trials is pictured below in Figure 4.5 and Table 4.4. There is no significant main effect of RC type on reaction time according to the linear mixed effects model. When plotting RT by group and including bilingual group and RC type as main effects (Figure 4.6 and Table 4.5), there is no effect of condition or group and no significant interaction between the two. In other words, RT results show no SRC/ORC asymmetry and no group differences.

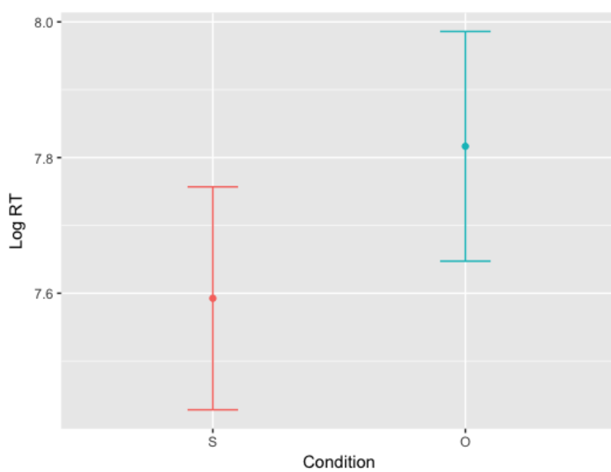

Figure 4.5: Log-transformed RT across groups

	Estimate	Std. Error	t value	Pr(> |t|)	
(Intercept)	7.57	0.20	38.29	<0.001	***
ConditionORC	0.22	0.15	1.50	0.15	

Table 4.4: Effect of RC type on log-transformed RT

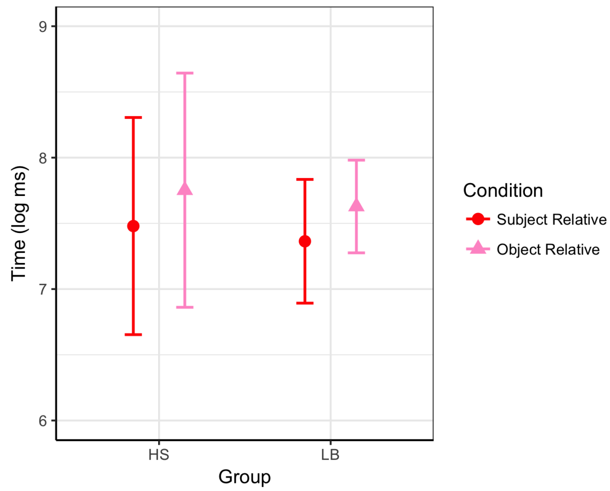

Figure 4.6: Log-transformed RT by group

	Estimate	Std. Error	t value	Pr(> |t|)	
(Intercept)	7.48	0.32	23.75	<0.001	***
GroupLB	-0.12	0.42	-0.28	0.78	
ConditionORC	0.28	0.21	1.29	0.20	
GroupLB:ORC	0.004	0.22	0.02	0.98	

Table 4.5: Effects of RC type and group on log-transformed RT

4.2.3 Gaze data results

Like response time, gaze fixation data are limited to trials where participants answered correctly. As an initial visual aid for understanding the gaze patterns throughout the trials, averaged proportions of fixations on each of the three images in normalized time are plotted in Figure 4.7 by group and by condition. The horizontal dotted line (at 33%) represents chance assuming that the participants are looking at the images rather than blank space, and vertical lines separate the four temporal regions. Proportion of fixation on the target image is represented in red, while the two distractors are plotted in blue and green.

Next, proportion fixations on the target image are binned and averaged then plotted for each region as can be seen in Figure 4.8. SRC average proportions are shown in red for each group, and ORCs are depicted in pink. Means and 95% confidence intervals are also plotted,

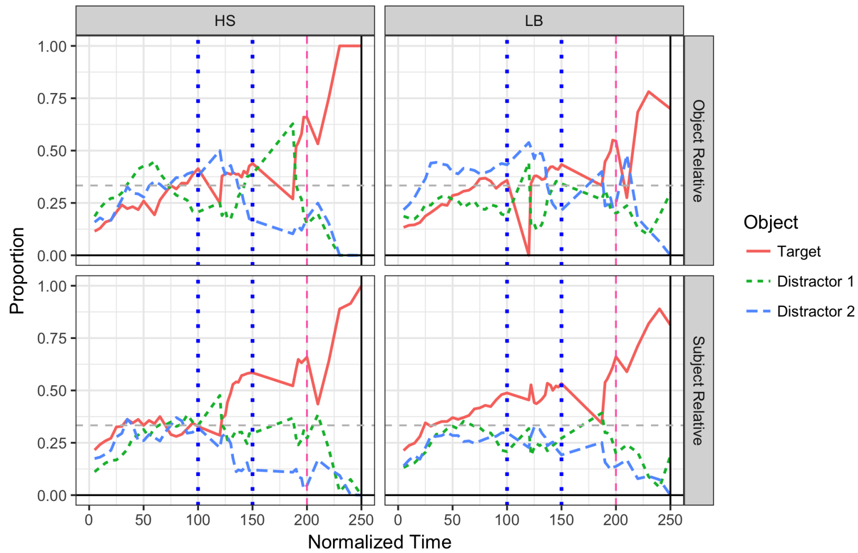

Figure 4.7: Proportion of fixations in normalized time

and the dotted horizontal line still represents chance. Regions 1 and 4 are not discussed in detail in this analysis, but this figure shows each group's proportion of target fixation for each condition in these two regions has no significant variance. This analysis focuses on the critical regions 2 and 3, which are now detailed.

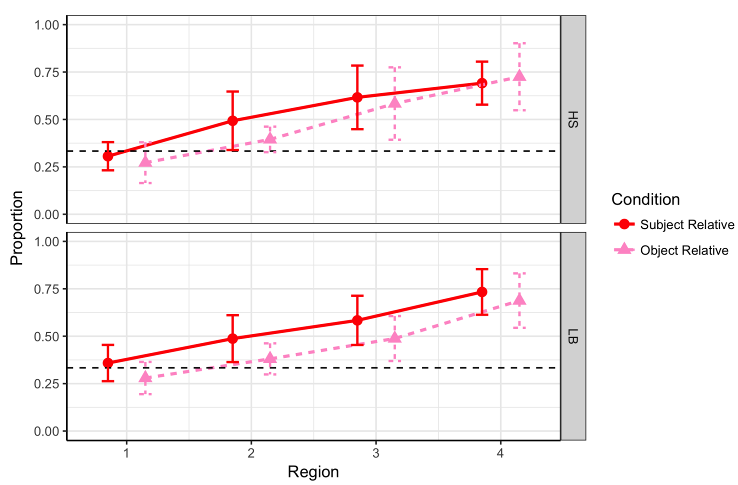

Figure 4.8: Target fixation proportion across regions

Region 2 proportion of target fixation by condition and by group is depicted in Figure 4.9. Confidence intervals for both groups fall slightly outside of chance in the SRC condition, but are not significantly better than chance in the ORC condition. An ANOVA test shows a significant effect of RC type on target fixation proportion in this region, $F(1,2) = 5.12, p = .02$, as well as an independent samples t-test across groups, $t(1124) = 2.65, p < .01$. However, a linear mixed effects model shows neither an effect of RC type nor bilingual group as shown in table 4.6. It is unclear whether the SRC/ORC asymmetry is present through gaze fixation in Region 2 based on mixed statistical results, but all statistical analyses show no effect of bilingual group in this region.

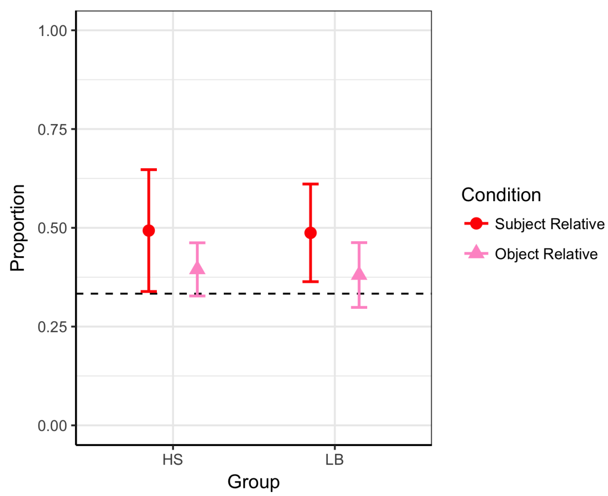

Figure 4.9: Region 2 target fixation proportions

	Estimate	Std. Error	t value	Pr(> |t|)	
(Intercept)	0.51	0.08	6.71	<0.001	***
ConditionORC	-0.11	0.10	-1.07	0.30	
GroupLB	-0.03	0.07	-0.39	0.70	
ORC:LB	0.01	0.08	0.14	0.89	

Table 4.6: Effects of RC type and group on target fixation proportion in Region 2

Region 3 means and confidence intervals by group and by RC type are plotted in Figure 4.10, and results of a linear mixed effects model can be seen in Table 4.7. In this region, target proportion fixations are all significantly higher than chance regardless of bilingual group or condition. There is a slight expected trend that ORCs have lower target fixation proportion than SRCs in both groups, and LBs have slightly lower target fixation than HSs in both conditions. However, there are no significant group differences or significant differences by condition. There is no main effect of group or RC type in this region, and there is also no significant interaction between condition and group.

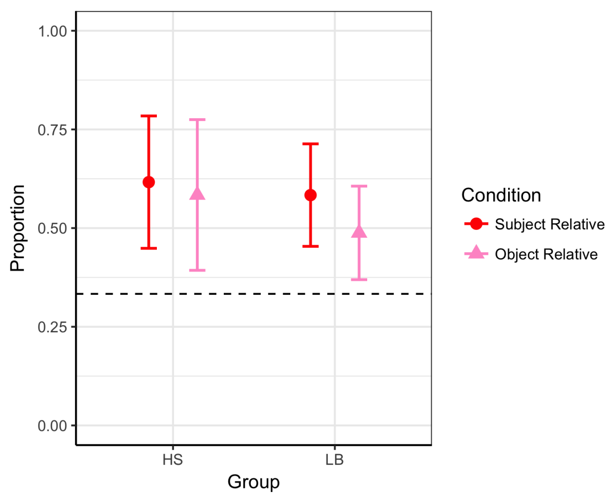

Figure 4.10: Region 3 target fixation proportions

	Estimate	Std. Error	t value	Pr(> |t|)	
(Intercept)	0.63	0.08	8.07	<0.001	***
ConditionORC	-0.04	0.09	-0.42	0.68	
GroupLB	-0.04	0.09	-0.49	0.63	
ORC:LB	-0.05	0.10	-0.51	0.61	

Table 4.7: Effects of RC type and group on target fixation proportion in Region 3

4.3 Discussion

The research question addressed in Experiment 1 has two main components: 1) Can a SRC/ORC asymmetry be found in these two bilingual groups? and 2) Are HSs and LBs patterning differently in their eye movements? These two components will be discussed in turn.

This data partially supports evidence for an RC asymmetry across these two groups. Accuracy data reflect that participants across groups are significantly more accurate on SRCs than ORCs. Additionally, in region two, there is some support that SRCs have significantly higher target fixation proportions than ORCs across all participants. The linear mixed effects model does not support this main effect though, and there are also no differences by condition with RT data or in the other three temporal regions. It is possible that the models are underpowered due to a small amount of participants and only 10 stimuli per condition, which is particularly evidenced by the conflicting results between t-tests and mixed effects models. This underpowering could be leading to false null results, and caution must be taken in this interpretation.

There is almost no support for any group differences in this experiment. Both groups had comparable target fixation proportions in each region and in each condition as well as similar RTs behaviorally. The only statistical analysis that shows any group difference comes from the accuracy data, where an independent samples t-test of variance in the ORC condition showed that LBs perform significantly worse on ORC accuracy than HSs. However, this is not confirmed as a significant main interaction effect with the generalized linear mixed effects model. As mentioned above, this could possibly be a result of underpowering for the model. However, even if the groups are performing differently in ORC accuracy, there are still no significant group differences in any of the gaze data analyses. In their second learned language, HSs and LBs are not processing relative clauses differently.

The lack of group difference does not support the predictive processing explanation used for these bilingual participants in Spanish (Stern et al., 2019). Rather, both groups seem to have an early SRC advantage (as was reported for only LBs in Spanish) but neither group is demonstrating a late ORC disadvantage. According to these results, neither processing nor prediction is different in the L2 English for HSs or LBs. The null results in group difference also do not directly support the overarching theme of this paper that language dominance may be playing a role in RC processing, as HSs overall should be demonstrating more of a SRC/ORC asymmetry if this were the case. However, since language dominance is not categorical but continuous and definitional group dominance assumptions should not be made for these highly proficient bilingual participants, further testing is required utilizing an objective measure of language dominance to tease apart its possible role in bilingual RC processing. This is the purpose of Experiment 2, which will now be discussed.

Chapter 5

Experiment 2: Language dominance

Given the possible presence of a SRC/ORC asymmetry in Region 2 in both bilingual groups and a lack of the asymmetry in either group during Region 3, it is difficult to tell what role, if any, language dominance may be playing in the processing of these participants. In order to overtly test for an interaction between language dominance and gaze fixation, explicit tests of dominance are needed. This is the purpose of Experiment 2: utilizing an objective measure to operationalize language dominance to test the relationship between an individual's relative language dominance and their patterns of gaze fixation which measure their cognitive focus. However, before this experiment can be detailed, more background on dominance and its measurement is required.

The concept of language dominance has long been present in bilingual literature (Lambert, 1955), yet there is no unanimous definition or means of measurement as it is a complex and multifaceted construct. A core and fairly unanimous understanding of language dominance is that it is inherently relative between both of a bilingual's languages. Isolating one language or the other is insufficient in depicting a bilingual's language experience. The language with higher relative proficiency, use, exposure, or a combination of any or all of these is often argued to be the dominant language. Dominance can vary greatly by dimension and domain, as a bilingual's oral language could pattern differently from their written language or similarly their dominant language at home may be widely different from the language they use more at work. Deciding which domains are most strongly at play in language dominance is a largely contested debate, and most research agrees that it is most beneficial to consider this multidimensionality in seeking to determine dominance (e.g., Birdsong, 2015). Finally, when defining dominance it is important to keep in mind that it is a gradient and dynamic construct. It is not categorical, but rather a continuous measure across a gradient scale between a bilingual's languages that can shift over time depending on relevant factors. The construct of language dominance is best conceived in relation to the construct of bilingual experience (Luk and Bialystok, 2013).

While defining language dominance is a difficult task in itself, additional difficulty arises when attempting to measure and operationalize the construct of dominance. Typically, dominance measures have been based on biographical variables or self-report. This method of collecting language background information and compiling it to create a relative dominance score has the benefit of being easy to administer and collect as well as having the ability to capture several factors that contribute to the multidimensionality of language dominance. However, measurements based on self-report vary in their reliability. While self-report has been shown to be effective in some studies of dominance (e.g., Luk & Bialystok, 2013), it can also be misleading or unreliable (e.g., Dunn and Fox Tree, 2009; Hakuta and d'Andrea, 1992) as language ratings may reflect language attitudes more than actual language facility. Additionally, HSs and LBs alike are often claimed to have linguistic insecurity in their HL and L2, respectively (Benmamoun et al., 2013; Ricento, 2005) which could lead to a misrepresentation of their own metalinguistic awareness. Finally, using a cumulative score that spans across domains and dimensions to represent dominance is problematic, as a global score of language dominance is virtually impossible and creates many confounds across domains.

Recently, there has been a call to use objective measures in operationalizing dominance

(Montrul, 2015). While objective measures are more difficult to administer and inherently focus on only one or two domains of language dominance, they offer much promise in reliably measuring aspects of dominance. Several objective measures have been created and utilized to operationalize dominance, such as body-naming tasks (O'Grady et al., 2009), picture naming tasks (Gollan et al., 2015), sentence repetition (Flege et al., 2002), and self-paced reading (Fernández, 2003). Speech rate is another direct assessment that has been argued to "offer the promise of relatively simple diagnostics of language proficiency" (Benmamoun et al., 2010, p. 21) for HS and LB populations. Several studies on HLs have utilized speech rate to measure HS proficiency (Kagan and Friedman, 2003; Polinsky, 2008a,0,0), and it is also well established as a method in SLA proficiency testing and in studies of language dominance (e.g., Treffers-Daller, 2011; Dunn and Fox Tree, 2009). An orally-based objective measure is particularly appropriate for studying the HS and LB populations in this paper, as it does not assume literacy in either language. Additionally, HSs receive mostly oral input in their HL. This strengthens the argument in favor of utilizing the oral domain to test relative dominance among these participants.

Based on the utility of objective relative dominance measures, the dangers of establishing global scores of dominance, and the appropriateness of oral tasks for the populations studied in this paper, Experiment 2 uses an oral fluency task in both English and Spanish to establish a relative language dominance index for the purpose of this study. It serves as a proxy for an individual's relative language dominance, though this paper does not argue that this index captures every aspect of such a complicated construct. However, it is the best manner of measuring dominance for the sake of this study in order to compare a single index to target fixation proportions from Experiment 1, which allows for an examination of the effect of language dominance on bilingual mental attention and the interaction between language dominance and processing in each of these conditions. Thus, this second experiment directly tests the second research question of this thesis:

ii) Can language dominance explain processing differences in highly proficient HSs and LBs?

5.1 Methods

5.1.1 Participants

The participants in this second experiment are the same individuals from Experiment 1 (n=18). That is, all participants who completed the relative clause eye-tracking study in English also completed the verbal fluency task for the Experiment 2 analysis. All 18 participants are highly proficient Spanish-English bilinguals residing in New York City, and are classified as LB (n=9) or HS (n=9) based on self-reported language background questionnaires and criteria commonly used in HS studies (Benmamoun et al., 2013). All participants were raised by their primary caregivers speaking Spanish until at least age 10, and self-report high proficiency in both English and Spanish. For a review of this information, please refer to section 4.1.1. Previous chapters present demographic information for these participants based on a language background screener by Li et al. (2006) and a questionnaire developed in the Second Language Acquisition Lab at the Graduate Center, CUNY. Additionally, these participants completed the Bilingual Language Profile (Gertken et al., 2014) which generates a quantitative measure of relative dominance in one language or the other based on responses to questions pertaining to history, use, proficiency, and attitudes. The value of the dominance score generated by the BLP is positive if the participant is Spanish-dominant, and negative if the participant is English-dominant. Table 5.1 reports the results of the four BLP dominance modules and the cumulative dominance score for these participant groups. Independent samples t-tests are also run for each score to test for variance between the LB and HS groups, and the significance values are included in the table. Three of the submodules (excluding language attitudes) reveal significant group differences, as well as the cumulative dominance score.

	LB	HS	variance
History	28.80 (11.94)	-3.78(11.27)	p<0.001
Use	6.18(19.53)	-18.89(14.27)	p<.01
Proficiency	6.05(7.00)	-10.34(7.87)	p<.001
Attitudes	22.70(19.71)	1.51 (17.14)	p=0.22
Cumulative	53.64 (49.74)	-31.50(41.00)	p<.01

Table 5.1: Participant BLP dominance scores

5.1.2 Task and data collection

Each participant completed a speech elicitation task using the picture book "*Frog, where are you?*" (Berman and Slobin, 1994), a commonly utilized method in gathering speech rate data with various populations including heritage speakers. The task was completed in both English and Spanish using different versions of the story, with the two versions alternating by language per participant. Spoken stories were transcribed word for word, including lexical and non-lexical fillers, by three research assistants. Data analysis began 30 seconds after the first meaningful utterance to account for start-up costs and allow the participants to gain comfort in the task. A word per minute speech rate was then calculated through the end of the transcription, both with and without fillers. Additionally, each participant completed the Bilingual Language Profile (BLP, Birdsong et al., 2012). The RF index and all other analyses were computed using R (R Core Team, 2018).

5.2 Results

5.2.1 Data analysis

Language dominance is operationalized in this study through the Relative Fluency (RF) Index. The RF index is computed following the model of Birdsong (2015) for dominance indexing based on calculations rooted in handedness. While many authors in the field of bilingualism use either a difference approach (Language A Score - Language B Score) or a ratio approach (Language A Score / Language B Score), this index formula is based on a combination of both. That is, this formula takes the difference of the language scores divided by the sum of the language scores. It then multiplies the score by 100 for the sake of ease of interpretation. For relative speech rate in this study, the formula is (Spanish WPM - English WPM) / (Spanish WPM + English WPM) * 100.

The WPM counts used for this index exclude code-switches, false starts, and non-lexical items but include all discourse markers since research widely argues that these lexical items have pragmatic and even syntactic function (e.g., Blakemore, 2002; Schiffrin, 2005; Fischer, 2006). The calculation is based on Spanish, every participant's first-learned language. This means that an RF index of 0 would indicate a speaker that is speaking at a fully balanced speech rate in Spanish and in English, a participant with a positive score is speaking faster in Spanish, and a participant with a negative score has a faster English speech rate.

To test for a main effect of language dominance on gaze fixation in the English relative clause eye-tracking experiment, linear mixed effects models are run for target fixation proportion in each region with Relative Clause type and Dominance (RF Index) as fixed effects and by-subject and by-item random intercepts. The results of the models for regions 2 and 3 are presented, along with the RF Index results, in the next section.

5.2.2 RF dominance index

First, to validate the utilization of the RF index as a dominance measure, it is correlated with the cumulative dominance index from the BLP (Birdsong et al., 2012) which is described in the participant section of this chapter. The RF Index is highly correlated with the BLP cumulative dominance across groups, $r(16) = 0.77, p < .01$. This shows that the RF Index is operationalizing dominance in a comparable way to the BLP Index which is an established indicator of bilingual language dominance. Next, to visualize the distribution of dominance scores across the two groups, Figure 5.1 depicts relative dominance by age of arrival. Each plot point represents an individual dominance score. Positive scores indicate higher Spanish dominance, while negative scores indicate faster English speech rate. HS participants are represented with red dots, and LB participants are represented with blue dots. Means and 95% confidence intervals are shown for each group with the black dot and error bars. The dotted black line represents a relative dominance index of zero, which would indicate an exact balance between Spanish and English in oral fluency.

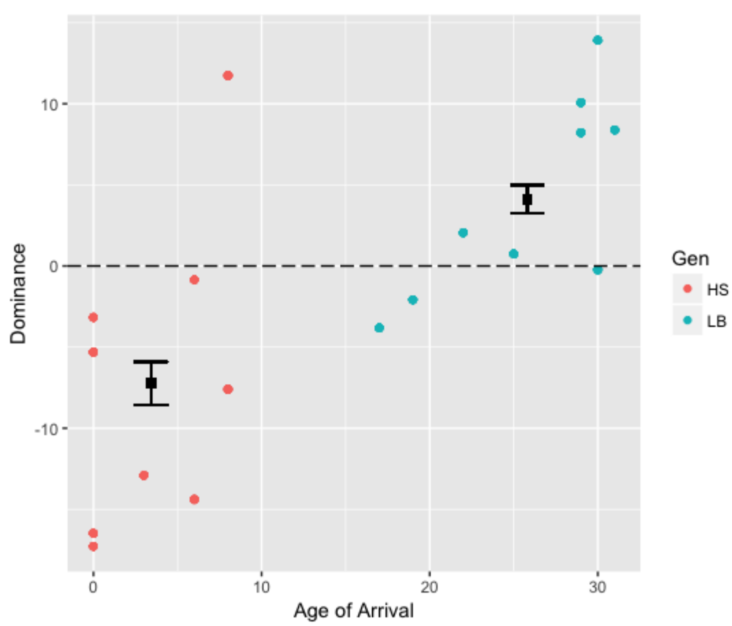

Figure 5.1: Relative dominance by age of arrival

There is a significant difference in relative dominance scores for LBs (*M*=4.14, *SD*=6.15) and HSs (*M*= -3.17, *SD*= 9.30) as indicated by an independent samples t-test: $t(13.9) = -3.10, p < .01$. Overall, the group means reflect an expected pattern of Spanish dominance for LBs and English dominance for HSs. However, as can be seen with the large deviation and the individual plot points, there is a lot of variation between these participants. In fact, some individuals indicate a relative language dominance that contradicts the direction of their group mean and typical definitional dominance assumptions for members of each of these groups.

5.2.3 Dominance and gaze data in Region 2

In Region 2, dominance (as measured by the RF dominance Index) does not have any main effect on target fixation proportions. As can be seen in Figure 5.2 and Table 5.2, there is only a very slight negative slope of gaze fixation as Spanish dominance increases. That is, participants who are more Spanish dominant are looking at the target image slightly less in both the SRC and ORC condition than participants with higher English dominance. However, this difference is not significant. Additionally, the interaction between dominance and condition is also not significant in this region. In Region 2, relative language dominance does not affect target fixation proportion and does not interact with condition.

	Estimate	Std. Error	t value	Pr(> $\|t\|$)	
(Intercept)	0.49	0.06	7.91	<0.001	***
ConditionORC	-0.10	0.09	-1.18	0.25	
Dominance	-0.002	0.003	-0.57	0.57	
ORC:Dominance	-0.0006	0.004	-0.15	0.89	

Table 5.2: Effects of RC type and Dominance on target fixation proportion in Region 2

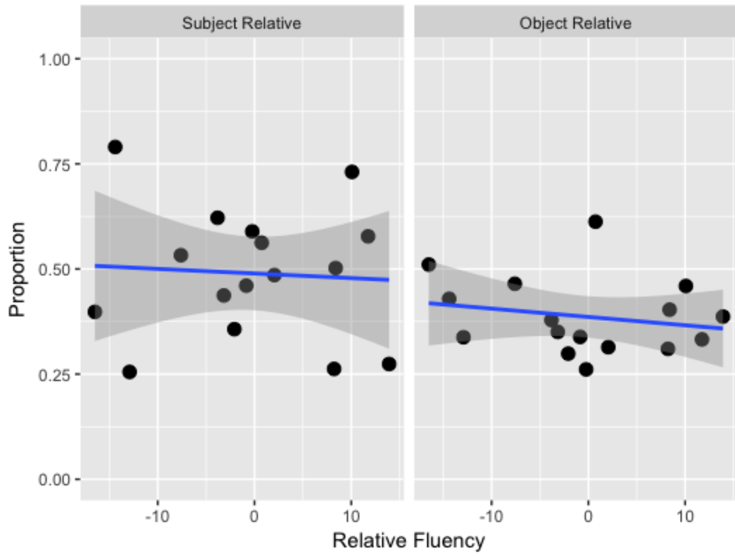

Figure 5.2: Region 2 gaze fixation by dominance

5.2.4 Dominance and gaze data in Region 3

Results for Region 3 are similar to Region 2, but the effect of language dominance on target fixation proportion in the ORC is more pronounced although still not significant. In Region 3, as illustrated in Figure 5.3 and Table 5.3, there is a negative relationship trend between target fixation proportion and higher Spanish dominance in the ORC condition and no correlation between target gaze fixation and dominance in the SRC condition. In other words, participants who are more Spanish dominant are overall looking at the target image less in the ORC condition than participants with higher English dominance. However, this difference is also not significant. As in Region 2, the interaction between dominance and condition is also not significant in this region.

	Estimate	Std. Error	t value	Pr(> $\|t\|$)	
(Intercept)	0.60	0.06	10.74	<0.001	***
ConditionORC	-0.07	0.07	-0.96	0.35	
Dominance	-0.0007	0.005	-0.15	0.88	
ORC:Dominance	-0.006	0.005	-1.03	0.30	

Table 5.3: Effects of RC type and Dominance on target fixation proportion in Region 3

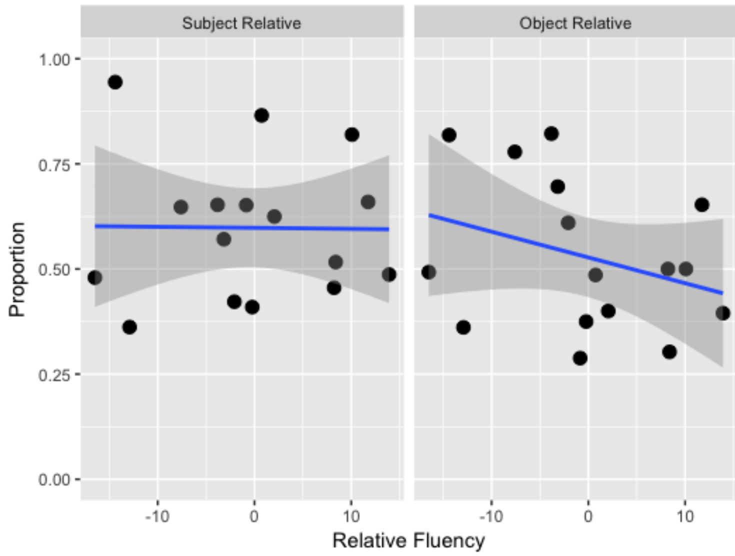

Figure 5.3: Region 3 gaze fixation by dominance

5.3 Discussion

Overall, the results of this experiment show no significant effect of language dominance on gaze fixation or an interaction between the two. However, as in Experiment 1, it is important to remember that these models are under-powered as they only have 16 participants and 10 stimulus items per condition. It is possible that analyzing a model with more participants could yield significant results, particularly with the ORC condition in Region 3. Additionally, since linear mixed effects models showed no significant effect of bilingual group on target fixation proportions in Experiment 1, this null result is unsurprising.

These results do not show support for the research question that was tested, which is: Can language dominance explain processing differences in highly proficient HSs and LBs? However, this is largely due to the fact that there were no processing differences found between these two bilingual groups in the eye-tracking experiment.

There is one strong benefit, however, of this paper's probe of language dominance: the RF Index seems to show promise in operationalizing dominance among these HS and LB populations in a relatively simple and not time-consuming way. Future studies should utilize this index in measuring bilingual language dominance to further probe it's viability in dominance research.

Chapter 6

Discussion and Conclusions

Although the two experiments yielded null results, they reveal novel and interesting findings. In accuracy, response times, and gaze data alike, both of the studied groups behaved exactly the same with these relative clause structures. Regardless of their different linguistic backgrounds and significant group differences in dominance, LBs behaved no differently in their non-dominant language than the English-dominant HSs. Both of these groups largely comprehended the structures, and their gaze fixation as they converge on the target image in each condition was not statistically different from each other. This reveals evidence in favor of the overarching idea of this paper that perhaps these two groups are more linguistically similar than they have historically been treated. However, it is important to keep in mind that the statistical models of the gaze data results are under-powered; therefore all interpretations of on-line findings should be made with caution.

Studies of highly proficient speakers of many languages across many methodologies have robustly attested that ORCs are more costly to process than SRCs, yet this asymmetry only received minimal support in this data. HSs and LBs alike are only partially showing any subject-preference or ease of processing, which previous literature on relative clauses cannot account for. It is possible that the bilingual brain as a whole is not using predictive processing or gap filling strategies in the dominant language of their larger society, but rather that they are more cognitively open to non-canonical linguistic possibility. Evidence supporting this has been shown in bilingual children (e.g., Filippi et al., 2015), but is unprecedented in a case like this with highly proficient adults in such a widely attested phenomenon monolingually and in second language acquisition studies.

Separately from the processing findings, the analysis of the RF Index which showed that some HSs are orally more dominant in their HL, Spanish, are a testament to the strong linguistic prevalence of the Spanish speech community in New York City (Otheguy et al., 2007). With rich linguistic input, HS language experience may not always result in a clear dominance in the societal majority language as their definitional background suggests. Spanish in NYC is a rare instance in the US of such a strong speech community that can allow a HS to maintain strong linguistic competence in their home language, but in the global context of migration more and more speech communities are emerging that allow for this HL richness. English is still heavily used in the community and still has a strong hold on these bilingual groups though, particularly as evidenced by the LB speakers that tested dominant in their L2.

This study as a whole is novel in two main ways. First, it looks at the non-heritage language processing of HS bilinguals. While English is the L2 of both groups and LB populations have been studied extensively in the L2 for acquisition research, no other real-time processing study to date has looked at the more dominant language in HSs. Looking more into the dominant language of this vital population could provide insight to its effect on the HL and on the linguistic profile of HSs as a whole. Second, it applies a new objective, relative index of language dominance that has shown to be useful and effective in measuring oral dominance among highly proficient bilingual adults. The Relative Fluency Index is encouraged for future studies of dominance as it is continuous, objective, relatively easy to collect and calculate, and it reflects both languages under one score.

Next steps for this project include continued data collection in order to give the models more statistical power for a clearer image of whether or not LB and HS processing varies in the processing of relative clauses. Additionally, beta regression models, which are better suited for proportion data, will be utilized to assess gaze fixation more acutely. This analysis of the gaze data could better represent the real-time processing during these trials.

There is much room for discovery in the psycholinguistic study of HSs and LBs in both of their languages. These two groups come from different linguistic backgrounds, but are crucially entwined and are similar in more ways than they are different. This thesis hopes to serve as a probe for future research in 1) the societal majority language of HSs, 2) the processing similarities between HSs and LBs, and 3) the role of relative language dominance in bilingual processing.

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