THE PHONOLOGICAL PERMEABILITY HYPOTHESIS: MEASURING REGRESSIVE L3 INFLUENCE TO TEST L1 AND L2 PHONOLOGICAL REPRESENTATIONS

By

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To my parents, Larry and Irene, and to my husband, Felipe
ACKNOWLEDGEMENTS

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G-1 Goodness task critical trials

G-2 Goodness task filler trials
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<td>Brazilian Portuguese</td>
</tr>
<tr>
<td>CAH</td>
<td>Contrastive Analysis Hypothesis</td>
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<td>CDA</td>
<td>Constraint Demotion Algorithm</td>
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<tr>
<td>CEM</td>
<td>Cumulative-enhancement Model</td>
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<tr>
<td>CFH</td>
<td>Constraint Fluctuation Hypothesis</td>
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<td>CON</td>
<td>the universal constraint set in Optimality Theory</td>
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<td>EEG</td>
<td>electroencephalography</td>
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<tr>
<td>EN</td>
<td>English</td>
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<td>ERP</td>
<td>event related potentials</td>
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<td>EVAL</td>
<td>the evaluator; an evaluation mechanism in Optimality Theory which determines the relationship between a candidate and the universal constraint set</td>
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<td>functional magnetic resonance imaging</td>
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<td>FTFA</td>
<td>Full Transfer/Full Access</td>
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<td>GEN</td>
<td>A generator of possible candidates in Optimality Theory</td>
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<td>GLA</td>
<td>Gradual Learning Algorithm</td>
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<td>L1</td>
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<td>L2SF</td>
<td>L2 status factor</td>
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<td>L3</td>
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<td>Phonological Permeability Hypothesis</td>
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<td>ROTB</td>
<td>richness of the base</td>
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<td>reaction time</td>
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<td>the emergence of the unmarked</td>
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By

Jennifer Lauren Cabrelli Amaro

August 2013

Chair: Jason Rothman
Major: Romance Languages

The Phonological Permeability Hypothesis (PPH, Cabrelli Amaro & Rothman, 2010) attempts to reconcile evidence suggesting some L2 learners, however rare, attain native-like L2 phonological systems with the observation that most do not. Considering existing L2 phonology research, it is not clear that phonological differences between early and late acquirers must be the consequence of maturational effects on implicit mechanisms. Thus, to test how native-like adult-acquired systems are, the extent to which early- and late-acquired systems are equally resilient to influence from an L3 is examined. The PPH posits that native-like phonological systems acquired in adulthood are different from systems acquired in childhood with regards to relative stability.

To test the PPH, a cross-sectional study of three types of English/Spanish bilinguals differing in age and context of acquisition (AoA) of Spanish was carried out to examine whether AoA determines relative vulnerability of the Spanish phonological system when exposed to L3 BP. In addition, a longitudinal case study was conducted, observing an L1 English/L2 Spanish bilingual’s Spanish prior to BP exposure, and his BP and Spanish after 11 weeks of BP immersion. The focus of the investigation was the acquisition of reduced word-final unstressed
vowels [ɪ] and [ʊ] in BP and potential regressive influence on the perception, production, and processing of Spanish word-final unstressed [e] and [o].

Results from the cross-sectional study did not reveal any between-group differences in perception, production, or reaction time in terms of BP influence on Spanish. Therefore, these data align with the possibility that AoA does not determine the relative stability of a phonological system in terms of mental representation or processing. However, while these data do not support the PPH, evidence meeting the criteria for falsification of the PPH is also lacking. The case study results are indicative of rapid and permeating L3 influence on the learner’s Spanish processing during speech production, and a large-scale longitudinal investigation of the three bilingual types tested here is necessary to reveal whether early and late acquirers of Spanish are equally vulnerable to L3 influence and what the nature of any observed vulnerability is.
CHAPTER 1
INTRODUCTION

1.1 Overview

Within the theoretical framework of generative language acquisition, it is proposed that humans are equipped with an innate language faculty that is modularly independent of other cognitive systems. This implicit cognitive mechanism, or Language Acquisition Device (LAD), consists of Universal Grammar (UG). UG is a set of language specific primitives that govern the structures of natural language (see, e.g., Chomsky 2007). As linguistic input is processed, sound-meaning correlations are formed and organized into a grammar that is delimited by the genetic language blueprint common to the species.

Under this approach, it is posited that children have full access to UG, and thus primary language (L1) acquisition in childhood is marked by overall success and uniformity (see e.g. Guasti, 2002; Hyams, 1986; Lust, 2006; Snyder, 2008). However, such uniformity is not evident among those who learn a second language (L2) after puberty (see e.g. Birdsong, 1999; Han, 2004; Herschensohn, 2007 for discussion), particularly within the realm of phonology (e.g., Bongaerts, 1999; Cranshaw, 1997; Flege, Birdsong, Bialystok, Mack, Sung, & Tsukada, 2006; Abrahamsson & Hyltenstam, 2009; Long, 1990, 2005; Major, 2001; Scovel, 1988, *inter alia*). Although there is strong suggestive evidence that the modules of morphosyntax and semantics do not suffer sensitive/critical period effects, at least not in the same way as phonology (see Rothman & Iverson, 2008; Rothman, 2008; Slabakova, 2008 for an overview of contemporary evidence, but see e.g., Beck, 1998; Dekeyser, 2003; DeKeyser, Alfi-Shabtay, & Ravid, 2010; Dekeyser, 2012; Hawkins, 2005; Long, 2005, 2007; Tsimpli & Dimitrakopoulou, 2007 for dissenting opinions from generative and other cognitive neurolinguistic perspectives), there is less definitive evidence for phonology than for morphosyntax and semantics. Nevertheless, it is
not clear that L1/L2 phonological differences, the existence of which no one denies, are the consequence of an inability to acquire the target system in the way that children do. In other words, there is a lack of definitive evidence that L1/L2 differences are a result of maturational effects on whatever implicit mechanisms are available to children, which is taken here to be UG.

Within the field of L2 acquisition, three variables have been widely postulated to explain the fact that L2 learners rarely achieve native-like phonological proficiency. The working hypothesis is that some combination of the following three variables conspire to explain the observable differences in phonological proficiency: (a) the effects of L1 transfer (e.g., Best & Strange, 1992; Campos, 2009; Hancin-Bhatt & Bhatt, 1997), (b) the possible loss of domain-specific linguistic mechanisms¹, and (c) physiological features such as articulatory constraints (see Wenk, 1979, 1983 for L1-transferred constraints and Colantani & Steele, 2007 for universal constraints) and perceptive ability as age increases (e.g., Flege, 1995; Scovel, 1988). The picture that emerges from the whole of L2 phonological research is, however, not at all clear. It remains to be determined which, if any, of these three components are responsible for the foreign accent that characterizes L2 speech.

As Long (2005) and Rothman (2008) independently point out, claiming a critical/sensitive period for any given domain denotes a can versus cannot dichotomy. Since critical/sensitive periods are maturationally conditioned, it is reasonable to suppose that there should be few, if any, exceptions to the predictions made by presuming critical/sensitive periods. Although the rarer case by far, researchers have reported instances of linguistically advanced individuals who master the phonology of their L2 to a degree that makes them no longer

¹ Such mechanisms include the ability to attend to necessary phonological triggers for restructuring, resulting from the filtering of L2 input through the L1 (e.g. Brown, 1998, 2000; Dupoux, Pallier, Sebastian, & Mehler, 1997; Kabuk & Istdari, 2007; Long, 2005, 2007; Matthews & Brown, 2004; but see Archibald, 1998; Young-Scholten & Archibald, 2000).
(reliably) distinguishable from native speakers of that language under the same empirical measurements (e.g., Birdsong, 2003; Birdsong & Molis, 2001; Bongaerts, 1999; Colantoni & Steele, 2007; Marinova-Todd, 2003). Given this possibility, it could be argued that there is no critical/sensitive period impeding native-like acquisition of phonological systems acquired after puberty and that something else causes the ubiquitous differences in ultimate attainment between L1 and L2 systems.

However, it is also possible that some individuals are phonologically talented, so to speak, in the sense that they have an ability to achieve a seemingly target-like non-native system on the surface via domain-general learning (e.g., a particularly good acoustic perception ability, relevant muscular dexterity, etc.), akin to so-called surface non-native morphosyntax success (e.g., Bley-Vroman, 1990; Clahsen & Felser, 2006; Hawkins, 2005, 2008; Hawkins & Casillas, 2008). Although virtually indistinguishable from native systems by the average ear, if there is a critical period for phonological acquisition, an L2 system should be distinct from native systems in its underlying mental representation and would thus be potentially perceptible under acoustic diagnostic scrutiny (see e.g., Abrahamsson & Hyltenstam, 2009, who found that native-like ratings of late L2ers did not hold up under acoustic analysis). Such a scenario would harmonize the evidence for a critical/sensitive period on the one hand, with the apparent exceptions to it on the other. Nevertheless, unlike in the case of L2 syntax, the difference between domain-general and domain-specific learning in the L2 phonological module cannot be easily disentangled since one cannot resort to robust cases of L2 poverty-of-the-stimulus supportive evidence to reasonably distinguish between surface and deep competence (but see Archibald, 2007).

In recent years, a multilingual generative research program has emerged which makes a crucial distinction between the L2 and L3/Ln acquisition process. Such a distinction had been
lacking for decades; historically, researchers did not distinguish L2 from L3/Ln learners. This practice could conceivably have given rise to much of the murky data reported in L2 acquisition studies from all traditions (see e.g., Rothman & Halloran, in press). As De Angelis (2007) points out:

. . . the field of SLA lacks a clear working distinction between those who are learning a second language and those who are learning third or additional languages….it is usually up to the researcher to decide whether learners' prior knowledge has the potential to bias the result of a study or not. Such freedom of choice, needless to say, conflicts with the most basic principles of methodological rigour in language acquisition research. While it may seem obvious to many that the prior knowledge of a non-native language is a variable that needs to be properly controlled, the reality is that the control for this specific variable is often poor, inadequate, if not lacking altogether. . . . (De Angelis, 2007, pp. 5-6)

What is clear is that the nascent field of generative L3 acquisition (L3A) is an area that is ripe for empirical investigation. In addition to its own internal L3/Ln questions, the study of L3A has provided novel and unique insights to inform unresolved debates regarding the mental constitution of native vs. non-native language systems more generally. Some L3A studies have presented evidence of the transfer of properties that could only have come via successful acquisition of new L2 mental representations, which we assume came about by means of continuous access to UG in adulthood. Such evidence shows, although indirectly, what has or has not been acquired in the L2, which we assume to represent what can or cannot be acquired in the L2 (e.g., Cabrelli Amaro, Iverson, & Judy, 2009; Iverson 2009, 2010; Leung, 2005, 2007). Additional research has revealed the possibility of investigating potential modifications to the existing native and non-native systems through examination of the L3/Ln (e.g., Cabrelli Amaro, 2013; Cabrelli Amaro & Rothman, 2010). This last line of investigation is the focus of the present study.

In light of the aforementioned, the present methodology is proposed as a way to determine potential differences (or lack thereof) in mental phonological representations between
pre- and post-pubescent successful learners. To do so, the study design used here compares the cross-linguistic effects of L3 phonological systems on a seemingly successfully learned/acquired L2 phonological system, compared to a native system of simultaneous and successive bilinguals with the same language pairings. This proposal is captured formally under the Phonological Permeability Hypothesis (Cabrelli Amaro & Rothman, 2010), which is explained in greater detail in Section 2.5.1.2. The present study endeavors to show whether the L2 phonological system demonstrates evidence of a significant difference from native systems by virtue of being more vulnerable to phonological influence from an L3 of typological proximity.

The investigation here tests specific predictions derived from the basic tenets of the PPH (see Section 2.5.1.2 for a presentation of such predictions), and the results stand to make an important contribution to our understanding of the emerging field of formal approaches to L3 acquisition. Additionally, this study offers further evidence supporting the idea that studying an L3 provides a novel source to test the claims/predictions of SLA theories/models by enabling the unraveling of variables that cannot be unraveled by looking at L2 acquisition alone (e.g., Bardel & Falk, 2007; Berkes & Flynn, 2012; Falk & Bardel, 2011; Flynn, Foley, & Vinnitskaya, 2004; Montrul, Dias, & Santos, 2011; Rothman 2010, 2011, in press; Rothman & Cabrelli Amaro, 2010).

1.2 The Research Problem

Despite the growing body of generative L3 studies, existing research functionally ignores the domain of phonology, almost exclusively examining morphosyntactic and lexical properties (but see Louriz, 2007). This dissertation will help fill this gap by examining how the study of L3 phonological systems affect (or not) native systems as compared to non-native systems acquired in adulthood. Perhaps the only way to truly resolve the question of the different natures of a native and non-native phonological system is to observe effects that result from the introduction
of a novel system. While a cumulative effect on multilingual acquisition has been discussed (see Berkes & Flynn, 2012; Flynn et al., 2004), such questions have not been considered within the realm of phonological acquisition and certainly not in the sense that the L3 could quickly and pervasively affect a seemingly successfully acquired L2 phonological system in a negative sense.

This research assumes a generative framework of phonological acquisition, which accepts the existence of a set of innate linguistic universals (UG) that aid acquisition. The generative framework also accepts that there is an abstract system, or grammar, in the learner’s mind which is comprised of features, hierarchies, or constraints that relate phonological and phonetic representations. While derivational accounts of generative phonology have been proposed to describe and account for the underlying representation of the phonological system, Optimality Theory (OT, Prince & Smolensky, 2004), offers an innovative approach in that it is able to elegantly and economically account for phonological transfer, markedness, learnability, and variability in acquisition at all levels of the phonological hierarchy and across all types of language learners (e.g. child and adult, monolinguals and multilinguals). OT is able to not only describe the structures found in natural language across all levels of phonology and all domains of grammar, but can also account for and make predictions for acquisition, gradual learnability and importantly, the erred and error-free variable outputs characteristic of a dynamic system. Given these facts, while there is still only a small (but promising) body of research in L2 OT (see Hancin-Bhatt, 2008 for an overview), OT is the most comprehensive theory within which to frame the investigation of native versus nonnative phonological systems and the ways in which they are modified (or not) as a result of input from a novel phonological system. OT’s superior ability to describe and explain such facts makes it ideal for the investigation of third language (L3) phonology, and thus is the framework that has been adopted to guide the testing of the PPH.

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2 See e.g., Kager (1999) for a discussion of OT’s principled account of economy phenomena.
1.3 The Research Proposal

This research examines the L3 acquisition of the Brazilian Portuguese (henceforth referred to as BP) sound system by native speakers of English who have already achieved a near-native level of proficiency in Spanish compared to simultaneous and successive bilingual speakers of English and Spanish learning L3 BP. Specifically, the impact of the addition of the L3 BP sound system on the Spanish sound system in each of these groups is investigated. Knowing that the acquisition of an L2 does not normally extensively affect the mental representation of a native language sound system (the exception being those who have spent a significant amount of their adult life in the environment in naturalistic L2 environments, see e.g. Major, 1992), this investigation seeks to understand why and how an L3 might affect an L2 system more pervasively and rapidly than an L1 system, even if the L2 sound system had previously reached a near-native level. The specific research questions that motivated the study are enumerated in the next section.

1.4 The Research Questions

Before contextualizing the current study by providing additional background information, it is necessary to introduce the research questions that will form the basis of this investigation.

1. Is the phonological system of a non-primary language acquired after a so-called critical/sensitive period significantly more vulnerable to instability than that of a primary language?

2. What do any possible differences of L3 influence delimited by age of acquisition tell us about the nature of a phonological system acquired before vs. after a critical period?

One cannot conclude based on observational patterns alone, no matter how robust, that pre- and post-critical period phonological acquisition is patently different simply because the outcomes are most often dissimilar. Since performance differences can surface for any number of confounding reasons that have little to do with representational deficits, it is important to test
beyond production (i.e., test perception for phonological discrimination) and to attempt to tap actual L2 phonological competence (Brown, 1998, 2000, *inter alia*). This can be done via the coupling of perception with production measures. However, this is not a failsafe methodology either, because learners are often metalinguistically trained to be aware of L1/L2 phonological differences at both the segmental and suprasegmental level. Even if they do not have such explicit metalinguistic awareness, the fact that they can perceive L1/L2 phonological differences does not necessarily mean that they are able to do so for the same reasons that L1 learners do. In other words, they may not have the same access to in-born linguistic primitives and/or access to the same language-specific acquisition mechanisms as L1 learners.

The remainder of this dissertation is organized in the following manner: Chapter 2 reviews the theoretical foundations that have given rise to this study and detail the PPH and the predictions that follow from it. Chapter 3 provides an overview of the phonological phenomenon and the predictions within OT. Chapter 4 presents the current study, detailing the methodologies implemented to test the PPH. Chapter 5 details the results of the perception experiment, while Chapter 6 reports the findings from the production experiment. Finally, Chapter 7 discusses the implications of the findings of the study for non-native phonological acquisition and attrition, and offers directions for future research.
CHAPTER 2
THE ACQUISITION OF PHONOLOGY

2.1 Overview

The current chapter provides a context for the present study, including the theoretical assumptions pertinent to this research. The discussion is divided into three parts. The first part of the chapter serves as an overview of generative research in L2 phonology, introducing how native and non-native acquisition are modeled in Optimality Theory (OT, Prince & Smolensky, 1993 [2004]). The discussion continues with two areas of non-native phonology central to the present study, L3 phonology and phonological attrition (i.e., modification), and how these might be modeled within OT. In the final portion, I present the Phonological Permeability Hypothesis (PPH) and the predictions generated by the hypothesis.

2.2 Generative L2 Phonology

Generative phonology can be traced back to Chomsky and Halle’s (1968) *Sound Pattern of English* (*SPE*), and is a component of generative grammar that relates underlying phonological and surface phonetic representations. While several generative accounts have been proposed to describe and account for phonological system, OT innovates in that it is able to elegantly and economically account for phonological transfer, markedness, learnability, and variability in acquisition at all levels of the phonological hierarchy (see Kager, 1999, for discussion).

As Hancin-Bhatt (2008) notes, the primary questions in L2 phonology research pertain to the definition of an interlanguage grammar, and how such a grammar is accessed during perception and production. These questions have been debated within a number of frameworks for well over half a century, beginning with the advent of the Contrastive Analysis Hypothesis (CAH), which focused on errors attributable to the learner’s native language (L1) (e.g., Lado, 1957; Stockwell, Martin, & Bowen, 1965), but was based solely on anecdotal evidence and could
not account for substitutions in the learner’s L2 for which the L1 was not the source. This section briefly reviews the history of non-native generative phonology, which, as Major (2001) notes, has generally paralleled what he terms ‘mainstream phonology’, a parallelism that reflects the idea that an overall framework for the analysis of L2 phonological learning must derive from an existing linguistic theory.

Chomsky and Halle’s *Sound Pattern of English (SPE, 1968)* was the first model that explicitly incorporated phonology into generative grammar. SPE assumes that linguistic input is parsed by context-sensitive rules, transforming an abstract underlying form into the phonetic form produced by a speaker. This transformation occurs via a linear ordering of rules where the output of each rule is the input of the following rule. SPE marked the advance of rule-based generative phonology, which dominated the field during more than two decades. As Kager (1999, p. 1) notes, however, there were few limitations on the rules and their interactions, and the field worked to refine the theory by constraining rule typology and interactions such that they adhered to a set of universal conditions. At the beginning of the 1980s (e.g., Chomsky, 1981) the efforts to constrain these rules culminated in the development of Principles and Parameters (P and P) Theory, which states that all languages are governed by a set of universal properties that cannot be violated, in addition to a set of parameters with (ideally) binary settings. The foundations of this theory are evident in generative L2 phonology, particularly in the 1990s.

Generative L2 phonology was still a nascent area in the 1980s and only began to truly flourish in the last decade of the 20th century. Notable research by pioneers such as John Archibald, Roy Major, and Ellen Broselow set out to determine whether UG was accessible in nonnative phonological acquisition and how universal principles might function in tandem with an L1 system to constrain L2 phonology, adopting the core tenets of the P and P approach.
However, there was an overall lack of discussion of the actual mechanisms involved in the resetting of phonological parameters. Research addressed the different levels of phonology, including the segment/phoneme (e.g., Major, 1986), the syllable (e.g., Broselow & Finer, 1991; see also Young-Scholten & Archibald, 2000, for a review of L2 syllable structure production research), and suprasegmental properties such as stress (e.g., Archibald, 1993a, 1993b, 1993c; Pater, 1993), and prosodic domains (e.g., Young-Scholten, 1994; Zampini, 1998). The assumption across this body of research has been that if an adult has acquired the property under investigation, she or he must have reset their parameters. This supposition is explicit in work by Broselow and Finer (1991) and Young-Scholten (1993) which investigates the resetting of the Minimal Sonority Distance (MSD) Parameter, and in Archibald’s (1993a, 1993b, 1993c) and Pater’s (1993) evidence of learners in the process of resetting metrical parameters.

However, within the body of research adopting a P and P approach, there has been no explanation of what it truly means to reset a parameter in L2 phonology, and not much discussion about how these findings relate back to phonological theory more generally. Models such as Major’s (2001) Ontogeny Phylogeny Model (OPM) are general and do not assume a specific framework. The OPM describes a dynamic system over the course of development in which the L1 decreases, the L2 increases, and U (which represents universals) increases and then decreases. The model serves as a solid foundation for a model of nonnative generative phonology, but leaves a lot of information to be determined in terms of the machinery involved and the inner workings of a system of universals.

Two exceptions from this era that specifically address the phonological mechanisms at work in L2 acquisition, however, are found in the work of Brown (1998, 2000) and Hancin-Bhatt (1994). Brown used Feature Geometry (e.g., Clements 1985), in which phonemes are composed
of a hierarchy of phonological features within UG, as a basis for the explanation of variable competence. She proposes in her Phonological Interference Model (PIM) that there is full copy of the L1 at the L2 initial state, and if a deterministic feature for an L2 representation is not part of the contrastive feature inventory in the L1, this feature cannot be contrastive in the L2, either. However, if the feature is used to distinguish other phonemes in the L1, then this contrastive feature is redeployable for new L2 phonemic distinctions. In other words, L2 access to a full feature inventory is an impossibility, but existing contrastive features can be redeployed for the acquisition of new contrasts.

Hancin-Bhatt (1994), on the other hand, proposed a mechanism for the determination of L2 segment substitutions. She outlined an algorithm to determine the value (what she refers to as the ‘functional load’) of a feature in a particular language, predicting that this value would determine the segment that substituted an L2 sound that was not part of the L1 inventory. Hancin-Bhatt’s results were not conclusive and Brown’s model does not formally explain how input is initially mapped or whether L1 structures are modified when they are deployed for L2 representations. However, both authors innovate in their attempts to define the machinery involved in the acquisition of a nonnative phonological system such that specific predictions can be made.

The research I have very briefly reviewed has served to establish the basic foundations of nonnative generative phonology research through the 1990s, and to establish the room there is for growth, particularly in terms of descriptive and explanatory adequacy. So, what is necessary to comprise a complete model of L2 phonology? The discussion now turns to an overview of the components of a comprehensive model, followed by an illustration of how OT best meets these requirements.
Hancin-Bhatt (2008) outlines the fundamental elements of an ideal model of L2 phonology, building on the requirements for models of L2 acquisition discussed in White (2000) and Grosjean (1998). In considering the scope of what a truly comprehensive model must cover, it becomes evident that the task is by no means simple. To begin, the model must account for all of the sound patterns and structures found in L2 grammars (as well as those that never should be evidenced) and must be generalizable across different levels of phonology. It also needs to account for the influence of levels of phonology over other levels, what Young-Scholten and Archibald (2000) refer to as the implicational hierarchy. Optimally, the model should generalize across domains, as well, extending to morphology, syntax, and semantics, as well as to domain interfaces. The different forms of input must be defined, as well as the way that each form impacts the system. The model must also address learnability, predicting acquisition and the ways and stages in which a grammar is restructured as it receives L2 input. Finally, it is necessary to explain the variation and variable competence (including task-based variability, which has often been treated as theory external) that is ubiquitous among nonnative speakers. This variation extends to a disparity between perception and production in terms of the rate of development, and the different cues and skills that are involved.

All of these requirements make for quite a tall order, and as of yet, the framework that has best been able to address these points has been OT. I now turn to a brief introduction to the theory and the way in which it satisfies the different requirements, as outlined in part by Hancin-Bhatt (2008).

2.3 OT

2.3.1 An Introduction to the Theory

OT, first proposed by Prince and Smolensky (1993 [2004]) and later developed by McCarthy and Prince (1995), moves away from the sequential approach that dominated the field
of theoretical phonology for more than twenty years, in favor of parallelism. Rather than a linear
set of language-specific, often arbitrary rules that determine the relationship between the
underlying representation of an utterance and its surface phonetic form, OT posits that a
hierarchy of constraints determines which outputs or input-output relationships satisfy particular
constraints in a phonological system. As seen in Figure 2-1, linguistic input enters the grammar
and the Generator (GEN) automatically generates a set of candidates. EVAL (the evaluator)
determines the relationship between the candidates and the universal constraint set (CON), at
which point the most harmonic output is selected.

The set of universal constraints is divided into two classes: FAITHFULNESS constraints
ensure that the output is as close to the input as possible, wanting every input sound to have a
corresponding output sound and vice versa. MARKEDNESS constraints reflect generalizations on
common (unmarked) and uncommon (marked) linguistic structures and ensure well-formedness.
While markedness is acknowledged to be an important component of phonological theory, it is
virtually absent from prior derivational theory. Together, markedness and faithfulness conspire
to determine the most optimal candidate from a limited set of candidates encoded within UG; in
the case of disparity between the input and output, MARKEDNESS constraints outrank faithfulness
constraints. Constraints are violable (unlike the inviolate principles in a P and P framework), and
the candidate with the least serious constraint violations is the most optimal. Constraints are
ranked relative to one another, and the severity of a violation is directly related to how high a
constraint is ranked. In the tableau in Table 2-1 that exemplifies the constraint interaction
proposed within OT, an asterisk indicates a violation of a constraint by a candidate, and an
exclamation point indicates a fatal violation, which eliminates the candidate. Candidate A
violates CONSTRAINT 1, the highest-ranked constraint, and is therefore eliminated. Both
remaining candidates violate CONSTRAINT 2, and so harmony with CONSTRAINT 3 ultimately
determines the optimal candidate. Since Candidate B fatally violates CONSTRAINT 3, Candidate C
wins. While constraints are universal and all languages are subject to their generalizations,
constraint interaction differs across languages, and so another language might have the same
constraints depicted in Table 2-1, but with a ranking of CONSTRAINT 2 >> CONSTRAINT 1 >>
CONSTRAINT 3. In such a case, Candidate A would win. The output resulting from these different
rankings is what makes one language different from another, while also limiting crosslinguistic
possibilities. Such a combination is a distinct advantage over the seemingly limitless rules
created within derivational phonology. OT is economical in its cognitive design, obviating the
need for the language-specific rules that were the axiom of derivational theory, and its inventory
of universal constraints has a distinct advantage over the “excessive machinery” (Kager, 1999, p.
187) of a derivational approach. Having outlined the basic tenets of OT, the next section details
how acquisition is modeled within OT.

2.3.2 L2 Acquisition in OT

OT not only allows us to address the outstanding questions and issues in the field of L2
phonology, but also crucially is a theory of grammar. OT is not unique to phonology, or even to
acquisition. It thereby adheres to a principle of economy, which is a tenet of generative grammar.
While a great deal of the research within OT is directed at phonology, the theory assumes that
that all types of linguistic input are managed via the mechanisms outlined in the previous
sections. Within phonology proper, OT is also able to address the interaction of the different
levels of phonology, and does so with a limited and therefore economical set of constraints that
addresses prosodic effects at all levels. There is even the possibility to address the clear asymmetry between perception and production, treating each as its own grammar.¹

As a comprehensive and yet parsimonious theory of grammar, OT is also able to account for acquisition (L1 and L2/Ln) and describe learnability in addition to the universal and language-specific features of a phonological system. The model is therefore economical in its mechanisms, and the interaction of universal constraints rids us of the need for special rules for L2 grammars or interlanguage grammars. In the following sections, I will describe two learning algorithms that model the acquisition process in OT.

Accounts of learnability within OT provide a clear picture of a dynamic system in which variation is a natural and expected occurrence. With access to UG, that is, to the universal set of constraints, an algorithm can rank and rerank constraints based on input. Two error-driven algorithms that demonstrate acquisition of constraint rankings have been developed over the last decade: The Constraint Demotion Algorithm (CDA) (Tesar & Smolensky, 1998), and the Gradual Learning Algorithm (GLA) (Boersma, 1997; Boersma & Hayes, 2001).

**The Constraint Demotion Algorithm.** Designed to model L1 acquisition, the Constraint Demotion Algorithm (CDA) assumes an initial state consisting of a hierarchy of constraints that are unranked and undominated. Stages of acquisition, which are separate grammars, are marked by the re-rankings of constraints, triggered by parsing failures in the form of positive evidence of a constraint violation in the winning candidate’s ranking. According to the CDA, the learner’s grammar detects rankings that produce a mismatch between the input and output, a process the authors refer to as Robust Interpretive Parsing. Once detected, the grammar compares the

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¹ Boersma and Escudero (2004) propose that input in a perception grammar is an auditory representation, and output is a phonological surface structure. On the other hand, a production grammar is an underlying lexical representation, and its output is surface structure (Prince & Smolensky, 1993 [2004]). For the purpose of this study, Prince and Smolensky are followed.
constraint violations of the winner and loser and the winner’s violations spur a demotion of the violated constraint. The Target State then consists of the constraint ranking that incurs the least serious violations in an optimal output.

**The Gradual Learning Algorithm.** While the CDA assumes discrete rankings, the Gradual Learning Algorithm (Boersma, 1997; Boersma & Hayes, 2001), which also alters rankings when input data conflict with its current ranking, follows a continuous scale of constraint strictness where higher values reflect higher-ranked constraints. The evaluation is stochastic, and the amount of space between constraints indicates the strictness of the relative ranking. Overlapping constraints yield free variation depending on the point of selection at evaluation time. Each constraint occupies a range on the scale, which the authors interpret as a probability distribution.

Two of the advantages to the adoption of the GLA, especially for L2 phonology, are the ways in which the algorithm can 1) account for optionality and variation, and 2) form grammars that generate multiple outputs due to the varying distance between constraints, which allows for flexibility of ranking. The accommodation of variation in the grammar is important, especially for nonnative grammars that exhibit ubiquitous variation and experience different stages of well-formedness before converging on a target ranking. Another important benefit of the GLA is that input containing speech errors, extremely common in speech among nonnative speakers, does not mislead the algorithm since rerankings are gradual.

Within the GLA, during evaluation selection points are picked and constraints are ordered according to these points. If this constraint order is a mismatch with that of the surface/output form, the algorithm goes to work to alter the constraint ranking values so that the grammar will be more likely to generate the optimal candidate the next time. The end state of the
grammar (to the extent that one exists) will reflect the ranking values of the constraints after exposure to a full range of forms, but only via gradual adjustments. Given what we know about the developmental stages of an L2 grammar, the GLA describes the nature of a nonnative grammar more adequately than the CDA, and its tenets are assumed for this dissertation.

**The L2 initial state.** In the case of L1 acquisition, it is assumed by many (e.g., Gnanadesikan, 2004; Smolensky, 1996) that constraints against phonological markedness outrank faithfulness constraints. Outputs will thus initially be unmarked, and the acquisition task requires promotion of faithfulness constraints that will lead to more marked surface forms. In L2 acquisition, the L2 initial state consists of the L1 scale of constraint strictness and access to all universal constraints, assuming the Full Transfer/Full Access hypothesis (FTFA) (Schwartz & Sprouse, 1996). Before any reranking occurs, learners evaluate surface/output candidates against their L1 rankings. If L2 input violates highly ranked faithfulness constraints in their L1, EVAL will rule out candidates with fatal violations. When L2 input violates these highly ranked constraints or when certain markedness constraints were never demoted during L1 acquisition, it is possible for effects of markedness constraints to emerge. The surfacing of such effects is known as the emergence of the unmarked (TETU) (McCarthy & Prince, 1994). In non-native phonology studies carried out in an OT framework, TETU effects have been frequently observed (e.g., Broselow, Chen, & Wang 1998; Bunta & Major, 2004). To illustrate one example, Broselow et al. (1998) present evidence of TETU in L1 Mandarin/L2 English coda-simplification data from Wang (1995). Learners simplified surface representations with illegal codas via epenthesis and deletion. The authors posit that NO OBS CODA, a markedness constraint which militates against obstruents in coda position, is undominated in the L1 Mandarin grammar. Thus, a syllable with a coda in English will fatally violate NO OBS CODA when evaluated by the
L1 Mandarin grammar. MAX (do not delete) and DEP (do not epenthese) are highly ranked faithfulness constraints in both Mandarin and English. However, the L2 data demonstrate a violation of these constraints, which is necessary in order to satisfy NO OBS CODA. Given that epenthesis and deletion are not productive processes in either Mandarin or English, it was unclear at first as to why learners selected candidates that violated MAX or DEP. On closer inspection, it was determined that the violation of one of the two constraints (which are unranked relative to one another) was due to a preference for disyllabic forms. However, disyllabic forms are not a requirement of Mandarin, and so the authors proposed that the markedness constraint WD BİN (words should consist of two syllables) is ranked below the faithfulness constraints MAX and DEP. Given that these faithfulness constraints are not normally violated in Mandarin (or English, for that matter), the effects of lower-ranked WD BİN do not surface in either language. Rather, these effects emerge in the learners’ interlanguage. In this case, as the learners gradually demote undominated NO OBS CODA as predicted by the GLA, such effects will subside, and learners’ grammar will begin to converge on the L2 rankings. As Hancin-Bhatt (2008, p. 138) notes, this convergence consists of faithfulness generally dominating markedness. While only one L3 study has been carried out within an OT framework, Louriz’s (2007) study of primary stress by Moroccan Arabic/French bilinguals acquiring L3 English also presents evidence of TETU, and thus it is necessary to consider the presence of such effects in L3 phonology studies.

Unlike previous accounts of generative phonology, OT is able to describe the structures found in natural language across all levels of phonology and all domains of grammar. Importantly, it can also account for and make predictions for acquisition, gradual learnability, outputs that do not conform to L1 or L2 target rankings, and the erred and error-free variable outputs characteristic of a dynamic system. Given these facts, while there is still only a small
(but promising) body of research in L2 OT (e.g., Broselow, Chen, & Wang, 1998; Bunta & Major, 2004; Goodin-Mayeda, Renaud, & Rothman, 2011; Hancin-Bhatt, 2000; Hancin-Bhatt & Bhatt, 1997; Hayes, 1999; Lombardi, 2003; Wiltshire, in press), the developmental grammars and variable competence that is typical of non-native phonological systems can be modeled and elegantly explained in a way that acknowledges the inherent variation of a linguistic system (see Hancin-Bhatt, 2008, for an overview). OT is the most comprehensive theory within which to frame the investigation of native versus nonnative phonological systems and the ways in which they are modified (or not) as a result of input from a novel phonological system.

2.4 Relevant Issues in Non-native Phonology

Two aspects of acquisition are central to the tenets of the working hypothesis of this dissertation, which claims that non-native phonological systems are more vulnerable than native systems to influence from an L3 (see Section 2.5.1.2), and therefore a review of the literature that addresses them is warranted in this chapter: The acquisition of an L3 phonological system, and the modification of existing native and non-native phonological systems. Each of these is discussed in turn.

2.4.1 The Study of L3 Phonology

As evidenced within the growing body of research in the field of third language acquisition (L3A), L3/Ln language learners are distinct from typical adult L2 acquirers since the former possess a larger repertoire of linguistic and, in many cases of successive bilingualism, metalinguistic knowledge (see e.g. Gogoi Rothman, Cabrelli Amaro, & de Bot, in press).² While research in L3 lexical acquisition and, more recently, L3 morphosyntax has burgeoned over the

² Herein, no distinction is made between L3 and subsequent language acquisition such as L4, L5, etc. (labeled Ln) despite prudent reasons for doing so methodologically in empirical research. Within the domain of phonology, as is true for all linguistic domains, previous linguistic exposure is a variable that one must account for and thus obliges a distinction between L3, L4, L5. However, such discussion is outside the remit of this dissertation (but see Hammarberg, 2010, for a discussion).
last two decades, the study of L3 phonetics and phonology is still in its infancy. Regardless of the reasons for which L3 phonology has not been a primary focus of acquisition research to date (see Cabrelli Amaro, 2012, for a discussion), its recent growth signals an interest in working toward an understanding of the multifarious processes involved.

While there is an established body of research on the facilitation of additional language learning (see Cabrelli Amaro, 2012, for a review), the bulk of L3 phonology research has focused on factors in L3 phonological transfer, and the question of which language(s) transfer(s) to an L3 phonological system has yet to be resolved. This is an important issue for the present study in terms of making predictions of what system(s) transfer(s) at the initial stages of the L3 modeled in OT. We can begin working toward this resolution by couching existing results within the models that have been proposed in generative L3 morphosyntax research and by implementing methodologies that allow for explicit testing of the models as they apply to L3 phonology.

2.4.1.1 Generative L3 morphosyntax models

As García-Mayo and Rothman (2012) note, the generative paradigm assumes that the process of language acquisition and its study can be divided into three parts: The initial stages, interlanguage development, and ultimate attainment. Generative L3 morphosyntax studies have focused (although not exclusively) on the initial stages due to the information those stages can yield regarding the cognitive underpinnings of what conditions transfer and how this information relates to linguistic architecture and cognition more generally.  

3 In fact, one of the most valuable contributions of L3 research is the fact that the mechanics of transfer can be observed in a way that is not possible in L2 research. In L2 research, transfer either occurs or not and there is only one possible source for this transfer (L1 > L2). However, looking at L3 transfer, there are two candidates for transfer (L1 > L3, L2 > L3), and thus researchers can observe the ways in which transfer is or is not selective.
Three models for L3 morphosyntactic acquisition have been presented within the generative framework: The Cumulative Enhancement Model (CEM) (Flynn, Foley, & Vinnitskaya, 2004), the L2 status factor (Bardel & Falk, 2007; Falk & Bardel, 2011) and the Typological Primacy Model (TPM) (Rothman & Cabrelli Amaro, 2010; Rothman, 2010, 2011, in press). All of these models assume some version of Full Access/Full Transfer (Schwartz & Sprouse, 1996), that is, they assume that all existing systems are available for transfer, and that there is unimpeded access to UG. Each of the models is discussed below.

**The Cumulative-Enhancement Model (CEM).** The CEM (Flynn et al., 2004; Berkes & Flynn, 2012) spans not only the initial state, but also developmental stages and ultimate attainment, and claims that any existing language system is available for transfer, but only as long as transfer is facilitative. This model considers as a primary factor the economy of language, such that non-facilitative transfer is predicted never to occur precisely because it would not be economical. With the evidence we have in various domains of L3 acquisition (e.g., Gut, 2010, whose study of vowel reduction observed non-facilitative transfer of fully realized vowels from the L1 to L3), we know this is in fact not the case, so this model is unable to account for transfer in a global sense. While there are L3 phonology studies that support the CEM (e.g., Tremblay, 2007, who found that L3 VOT values reflected facilitative L2 transfer), the methodologies of those studies were not designed to test all three models and/or were not implemented in the initial stages of acquisition, and therefore support of the two other models cannot be ruled out.4

**The L2 Status Factor.** The L2 status factor, also referred to as the foreign language effect (Meisel, 1983), claims that the L2 system will always be favored for transfer to the L3.

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4 This study also supports the L2 status factor.
yielded the original proposal for an L2 status factor for L3 acquisition, forming the foundation for Bardel and Falk’s (2007) work on an L2 status factor for L3 morphosyntax. Bardel and Falk posit that the L2 maintains a privileged status due to the higher degree of cognitive similarity between two non-native linguistic systems, following Paradis’ (2004) neurolinguistic theory of bilingualism, as opposed to between a native system and a non-native system. The model applies only to successive bilinguals that have acquired an L2 after adolescence, and does not assume an L2 status factor for speakers that have acquired an L2 naturalistically as a pre-adolescent. However, they do not wholly discount language distance and psychotypology as possible intervening variables, but state that it is unclear how closely related the language pairing must be to trump the L2 status factor (Bardel & Falk, 2012).

Tremblay (2007), Llama, Cardoso, and Collins (2010), and Wrembel (2010) all present evidence in support of the L2 status factor, but there are methodological limitations in all cases. Tremblay’s (2007) results also support the CEM, as discussed in the previous section, and Wrembel’s (2010) methodology, similarly to that of Rothman and Cabrelli Amaro (2010), did not allow for the teasing apart of an L2 status factor from psychotypology. In addition, a follow-up study (Wrembel, 2012) that employed different groupings of language pairings to control for language distance (L1 Polish/L2 French/L3 English), yielded evidence in favor of psychotypology, which will be discussed further in the next section.

Llama et al. (2010) found in favor of an L2 status factor, employing mirror-image language pairings as has been done in several studies of L3 morphosyntax. Observing VOT in L1 English/L2 French and L1 French/L2 English learners of L3 Spanish, compromise L2 VOT values were virtually identical to the L3 values for both groups, even though the difference between learners’ intermediate L2 English and French VOTs were great. However, several
methodological issues lead to a questioning of the findings. First, the results for the L1 French group were not statistically significant, and thus should not be considered to support the L2 status factor. Second, the authors used monolingual VOT values to compare to the L2 and L3 VOT values, rather than testing the L1 VOT values of the learners for direct comparison. This is problematic, as it is possible that the learners’ L1 value was modified during L2 acquisition, closer to the value transferred to the L3, which would then find against an L2 status factor since a modified category (a hybrid of the L1 and L2 values) could have transferred (see e.g., Tremblay, 2007, for evidence of hybrid transfer). The authors acknowledge the lack of L1 testing as a weakness, but still maintain that their results favor an L2 status. Finally, because the learners were tested after the initial stages, it is not possible to determine whether the learner actually transferred his L2 or if learning had taken place and generalizations had been acquired by virtue of exposure to the L3.

Cases of combined transfer (successive, e.g., Hammarberg & Hammarberg, 2005; and simultaneous, e.g., Barkley, 2010) also provide evidence against L2 absolute transfer and therefore the L2 status factor. In theory, combined transfer should support the CEM, but while the majority of L3 phonology data may not be sufficient to discount the CEM due to methodological design that does not allow for the observation of the selection of a non-facilitative language, extensive data from L2 phonology research as well as copious anecdotal evidence show that non-native phonology is tinged with non-facilitative transfer. Thus, it is a strong possibility that the CEM will not be supported by L3 phonology research.

**The Typological Primacy Model (TPM).** The TPM shares a common thread with the CEM in that both models maintain that transfer of morphosyntactic properties can originate from any previously acquired system, and there is no default transfer from either the L1 or L2.
However, the TPM makes different predictions from the CEM, as transfer is seen to be selective and motivated by (unconsciously) perceived structural similarity. Unlike the CEM, the TPM thus predicts that transfer can be both facilitative and non-facilitative. According to Rothman (in press), transfer occurs via an internal mechanism (the linguistic parser) that determines the system that best matches the L3 according to a hierarchical continuum of linguistic information. At the initial stages of the L3, said internal mechanism determines similarities first in terms of the lexicon, followed by phonology, morphosyntax, and semantics. Rothman explains that the continuum is organized in such a manner because “detecting lexical similarities is much more straightforward than detecting phonological similarities, morphological similarities and finally syntactic similarities, in this order” (Rothman, in press, p. 41).

The combination of Wrembel’s (2010) aforementioned evidence of L2 to L3 transfer and data from her (2012) study of global accent in L1 Polish/L2 French/L3 English speakers supports the TPM. In the 2012 study, regardless of proficiency or stage of acquisition, the L1 phonology was dominant in the learners’ L3 productions. Looking at the results of the two studies together that demonstrate influence from the L2 in one case and L1 in the other, Wrembel concludes that L2 influence on L3 phonology is conditioned by structural similarity. Barkley (2010), using a mirror-image methodology in her study of the acquisition of L3 BP by English/Spanish successive bilinguals found that, while there was evidence of both L1 and L2 influence, structural similarity trumped language status. The difference between English and Spanish transfer to BP was significant, regardless of Spanish’s status as an L1 or L2.

As seen, the above models of transfer provide a solid foundation upon which to attempt to construct workable and verifiable models to encompass other domains of grammar and where the models could be amendable to other cognitive psycholinguistic paradigms. This would be the
ultimate goal since transfer is a notion used in all cognitive theories of language and its mental representation. However, as they were developed for the specific domain of morphosyntax, there are elements that these models lack when applied to L3 phonology, one of which is how to address combined (i.e., hybrid) transfer. None of the morphosyntax studies carried out has addressed combined L1 and L2 transfer, which has been observed in L3 phonology (e.g., Blank & Zimmer, 2009; Pyun, 2005; Tremblay, 2007; Wunder, 2010). Observation of L3 phonology via acoustic analysis is particularly valuable to the development of L3 models as combined transfer of separate linguistic systems can be seen within a single hybrid segment, as shown in Blank and Zimmer (2009), Tremblay (2007), and Wunder (2010). To be fair, acoustic analysis provides a much more direct and measurable assessment tool that is unequalled in the realm of morphosyntactic abstraction as it relates to determining representation, and makes it possible to build holistic evidence in support of a model at all levels of the linguistic system.

**The L3 initial stages and OT.** Given that the L3 morphosyntax models assume a generative paradigm, OT is an appropriate framework within which to test these models, as it allows for the analysis and explanation of acquisition (and within acquisition, variability), markedness, and transfer.

Only one published study to date has observed L3 phonology within OT. As mentioned earlier, Louriz (2007) used OT to look at L3 phonological transfer at the initial stages, finding evidence that existing systems were blocked by universals when it came to primary stress. Her research innovates in that it does not focus solely on learner errors, but analyzes interlanguage as a whole to understand the constraint rankings of a complex system. The use of OT for L3 phonology analysis allows for the observation of how the constraints for each existing linguistic system interact and how the rankings behave when faced with a new system. The L2 learner
begins with her L1 constraint rankings and has access to all possible constraints in language by way of UG. Upon exposure to the L2, the learner will rerank the constraints to the specifications of the L2 grammar. The question then becomes, what does a learner start with when exposed to a third language?

Louriz determined the constraint ranking of the L3 learners she observed with respect to primary stress in trisyllabic and polysyllabic nouns in their L3 English, and then compared it to the learners’ constraint rankings for primary stress in L1 Moroccan Arabic (MA) as well as their L2 French. Within OT, access to universals (i.e., UG) is unimpeded and since constraints are an instantiation of UG, all constraints are accessible, and the results support this. The undominated constraint ALIGN-L (Ft, PWd) that motivates an output of penultimate stress in trisyllabic nouns and antepenultimate stress in polysyllabic nouns is not activated in any of the languages to which the learners had been exposed and was evidenced to be the result of access to UG.

While the aforementioned study is well done and the results point to a ranking dominated by influence from universals and full, unimpeded access to UG for L3 phonology, there are limitations to Louriz’s study and a need for further research before any strong claims can be made. It is important to continue testing L3 constraint rankings for other properties at the segmental and suprasegmental levels and consider the predictions that each of the L3 models makes within OT. Depending on the evidence we see in L3 constraint rankings in relationship to L1 and L2 constraint rankings, there are certain implications for the L3 models, which are described below. It should be noted that a mirror-image methodology and testing in all three languages is necessary to properly test the predictions of each model.

- **CEM:** If neither the L1 nor the L2 constraint ranking is facilitative, the brain will rely on universals to provide a ranking for economic reasons. Louriz’s (2007) results support the

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5 While Louriz claims that the learners were at the initial stages of L3 English acquisition, they had been studying English for upward of one year. Better evidence would be to find this much earlier in the acquisition process.
CEM, since none of the existing systems’ rankings were evident in the participants’ productions of L3 English nouns.

- **TPM**: The ranking of the linguistic system perceived to be the most similarly structurally will transfer. Louriz’s results do not support the TPM, given the supposition that French would be perceived as typologically more similar to English than MA and therefore the ranking leading to word-final stress in the case of a heavy syllable not containing a schwa or low vowel should transfer to L3 English.

- **L2SF**: Louriz’s experimental group does not allow for consideration of the L2SF. With the implementation of mirror-image experimental groups, support for the L2SF would take the form of an L1 MA/L2 French/L3 English group transferring the French ranking mentioned above, and an L1 French/L2 MA/L3 English group transferring the MA ranking. These rankings would lead to trochaic feet in words in isolation, iambic feet in words in context and a stressed penultimate syllable in English.

In the following section, the three models discussed here will be considered with respect to the languages that are investigated in the current study, English, Spanish, and Brazilian Portuguese (BP).

### 2.4.1.2 Transfer at the initial stages of L3 BP

Spanish and BP are typologically very similar languages. Garrison (1979) posits that few languages share as many structural similarities, and estimates that 80% of the lexical items in Spanish share a cognate in BP. Jordan (1991) opines that the most significant differences between the two languages are morphological and phonological. There are three factors that motivate a prediction for transfer of the Spanish system at the L3 initial stages driven by structural similarity. First, there is strong evidence in favor of the TPM from L3 morphosyntax research, much of which tests the same language pairing tested here (e.g., Cabrelli Amaro, 2013; Giancaspro & Halloran, in press; Iverson, 2010; Montrul, Dias, & Santos, 2011; Rothman, 2010). Given that the TPM maintains that a linguistic system is transferred in its entirety (as opposed to piecemeal, i.e., property-by-property), Spanish transfer to L3 BP is predicted for phonology, as well. Second, the majority of L3 phonology research (Barkley, 2010; Wrembel, 2010, 2012) that has employed the mirror-image methodology necessary to test L3 initial stages
transfer models supports the TPM.\textsuperscript{6} Third, a pilot study (Cabrelli Amaro & Rothman, 2010) that tested the phonological production of two L1 English/L2 Spanish speakers and two heritage speakers of Spanish demonstrated categorical Spanish transfer at the L3 BP initial stages. Taking all of this evidence together, I predict that all of the experimental groups will transfer their set of Spanish constraint rankings at the initial stages of L3 BP independent of the status of the Spanish system as an L1 (early-acquired) or L2 (late-acquired). If non-native learners transfer their Spanish constraint rankings, it will be possible to observe what has been acquired in the L2, which is the focus of the next section.

2.4.1.3 Informing debates of non-native phonological acquisition

Observing the acquisition of an L3 in its initial stages allows not just for the testing of hypotheses of complex transfer; its study can inform ongoing debates in the field of language acquisition, including accessibility to innate linguistic knowledge, linguistic architecture, and economy. For example, within a generative paradigm, Cabrelli Amaro, Iverson, & Judy (2009) and Iverson (2009, 2010) show that the study of morphosyntactic transfer at the L3 initial stages provides a unique, complementary window of inquiry for the testing of L2 steady state theories regarding Universal Grammar (UG) accessibility. The aforementioned studies demonstrate that UG is accessible in general to adult learners via evidence of L2 functional categories and features acquired in the course of L2 acquisition that are present in the L3 initial stages. In such cases, access to UG is the only explanation as to how such features were acquired during the L2 process, as the L1 is devoid of such formal features. Several L3 phonology studies have produced results that support these findings and conclusions, such as those of Blank and Zimmer.

\textsuperscript{6} Recall that Llama et al. (2010) reported findings in favor of the L2 status factor, but the data from the L1 French group was not statistically significant. Therefore, it is not possible to conclude that the L2 English system (the typologically less similar language of the pair) was transferred to L3 Spanish. See section 2.6.1.2 for a full discussion of the methodology.
(2009), Gut (2010), Louriz (2007), Pyun (2005), and Tremblay (2007). With evidence of parameter resetting in the form of L1 and L2 phonological processes and phonetic characteristics such as F1, F2, and duration in their L3 systems, this work also supports the overwhelming conclusion of L2 phonologists that transfer to the L2 phonological system is comprised of a combination of L1 parameters and UG access (see Eckman, 2004, for a review), in a way that the study of L2 phonology has not been able to demonstrate in isolation. Crucially, as it relates to the PPH, this evidence motivates the prediction that even the late acquirers of L2 Spanish will transfer a full system of Spanish constraint rankings at the initial stages of L3 BP. After a discussion of progressive transfer and the light it can shed on questions of cognitive organization and debates of L2 acquisition, the focus shifts to regressive transfer.

2.4.2 The Modification of Existing Phonological Systems: L1 Attrition

While to my knowledge there is only one study that examines L3 effects on L2 phonological systems\(^7\) and no existing research examining differential effects on an L1 vs. L2, there is an established body of research on the effects of a late-acquired L2 on an L1 phonological system. In this study, I assume Iverson’s (2012) definition of attrition as the “erosion of first language competence after exposure to another language” (Iverson, 2012, p. 7). Employing such a broad definition affords the encompassing of a variety of linguistic profiles. These profiles include the experimental participants that are the focus of this dissertation: Adult L2 language learners and heritage speaker bilinguals; that is, bilingual speakers that have been raised with a language at home that is not the dominant language of the society in which they live.

\(^7\) Gut (2010) found no evidence of influence from L3 vowel reduction and speech rhythm on the L2 English or German of four trilingual speakers whose L2/L3 pairing was English/German (n=2) or German/English (n=2).
Attrition can present itself in various forms, ranging from minor modifications such as changes in voice onset time (VOT) of stops (e.g., Caramazza, Yeni-Kamshian, Zurif, & Carbone, 1973; Flege, 1987; Major, 1992) to what has been termed as language death (e.g., Dorian, 1981) as a result of extended contact with another language across generations. Major (2010) divides the study of L1 attrition into macro and micro levels, with the macro level investigating languages that have been in contact for more than one generation. The micro level of attrition research consists of the investigation of a smaller number of speakers (as opposed to a community of speakers) that have acquired an L2 in adulthood. Given the scope of this dissertation, I will frame the discussion of L1 attrition with a general overview of language contact research, from which point I will focus on research on modification of existing phonological systems at a micro level and the predictions borne out of this research.

2.4.2.1 Macro-level L1 attrition: Language contact

Research stemming from a long tradition of investigation of languages in contact has presented a body of evidence that speakers with multiple linguistic systems evidence bidirectional influence between languages (e.g., Bond, Stockmal, & Markus, 2006; Guion, 2003). As a result, it is generally accepted that the individual linguistic systems of a bilingual are not qualitatively comparable to the linguistic system typical of a monolingual speaker of the same language. There are several studies to this effect that have examined bilingual populations in language contact situations, starting with the classic study by Caramazza et al. (1973). The authors investigated perception and production of voice onset time (VOT) by monolingual English and French speakers and bilingual L1 French/L2 English speakers in Canada (a subset of which were heritage speakers of French) with an age of onset of no more than 7 years. The bilingual population produced intermediate VOTs and perceived intermediate voicing contrasts. Subsequent research has confirmed Caramazza et al.’s (1973) findings, presenting evidence of
bidirectional influence in Quichua/Spanish vowels (Guion, 2003), French/English vowels (e.g., Bullock, Dalola, & Gerfen, 2006, and Russian/Latvian vowels (Bond et al., 2006).  

2.4.2.2 Micro-level L1 attrition

The language contact research reviewed in the previous section paved the way for L1 attrition research at the micro level as classified by Major (2010). To illustrate this classification, Major uses the example of a Bostonian that has acquired L2 French in adulthood and is currently living in France. If this speaker’s English is different from that of a monolingual Bostonian, attrition has occurred.

An impressive body of work in micro-level L1 attrition has surfaced in the last decade, as evidenced in part by a volume edited by Schmid, Köpke, Keijzer, and Dostert (2007), numerous doctoral dissertations (e.g., de Leeuw, 2008; Iverson, 2012; Lubinska, 2011), special issues of the International Journal of Bilingualism and Language, Interaction and Acquisition, and Schmid and colleagues’ language attrition website hosted by the University of Gröningen (http://www.let.rug.nl/languageattrition). As noted by de Leeuw, Schmid, and Mennen (2010), the majority of the work has concerned morphosyntactic attrition (e.g., Gürel, 2004, 2007; Iverson, 2012; Kreijzer, 2010). While there are considerably fewer phonological attrition studies in comparison, an analysis of existing data from L1 attrition research across linguistic domains yields a number of testable predictions for phonological attrition, and specifically for the PPH.

L1 phonological attrition. The most cited studies of L1 phonological attrition examine the voice onset time (VOT) of stop consonants. Flege (1987) examined L1 French speakers living in the US and L1 English speakers living in France, while Major (1992) examined L1

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8 Given that Major cites the results presented in Caramazza et al. (1973) and Bullock et al. (2006) as examples of macro-level L1 attrition, I assume here that heritage speakers fall under the umbrella of macro-level L1 attrition.

9 Admittedly, this is a simplistic view of attrition (see Iverson, 2012; Schmid, 2011 for a discussion of the different populations and contexts in which attrition is relevant). However, for the present study, it does the job of describing one of the participant populations investigated here.
English speakers that had been living in Brazil between 12 and 35 years. Both studies provide evidence of L1 VOTs that were similar to the VOTs of the L2. In Major’s study, he found a relationship between L2 proficiency and L1 attrition, such that the learners’ with higher L2 proficiency evidenced more L2-like VOTs in their L1. More recent studies of VOT support Flege’s (1987) and Major’s (1992) results. Bullock, Toribio, González, and Dalola (2006) examined VOTs in the code-switching of L1 Spanish/L2 English and L1 English/L2 Spanish speakers, and found that the speakers’ VOT values underwent gradient changes depending on language mode. In code-switching contexts, while the L1 Spanish learners’ Spanish VOTs were in line with those of monolinguals, the L1 English learners’ English VOTs were not. However, in monolingual English mode, the attriters produced VOTs that were similar to those of monolinguals. Lord’s (2008) study of the VOT values of advanced L2 Spanish speakers also produced evidence of compromise VOT values, although the results partially contradict those of Bullock et al.: The English data were produced in a monolingual English context, as opposed to in a code-switching context, and still evidenced compromise VOT values. Interestingly, the fact that both of the attriting groups in these studies had remained in their L1 English community indicates that L1 phonological attrition is not limited to situations in which the L2 is the dominant language.\(^\text{10}\)

Modification of the L1 phonological system is evident not just at the segmental level, but in global foreign accent as well. A case study by Sancier and Fowler (1997) followed an L1 BP/L2 English speaker over the course of a year, during which the speaker traveled from the US to Brazil twice. Speech samples taken after each trip were submitted to foreign accent ratings,\(^\text{10}\) However, the relative degree of attrition might be different (see subsection ‘Predictions for the PPH’).
and judges were able to differentiate between the English samples taken before and after extensive exposure to BP.\textsuperscript{11}

While the abovementioned studies make a strong case for L1 attrition, at least in terms of VOT (and perhaps foreign accent, although generalizations cannot be made based on a single case study), some research indicates a resistance to L2 influence on the L1. Bullock et al.’s (2006) Spanish VOT data from the code-switching condition for the L1 Spanish speakers did not differ significantly from the Spanish VOT control values. Resistance to L1 compromised VOTs was also found in a study by Riney and Okamura (1999) in L1 Japanese/L2 English speakers as well as L1 English/L2 Japanese speakers in Japan. Finally, de Leeuw, Schmid, and Mennen (2010) presented evidence of L1 German stability in L2 Canadian and Dutch contexts that inhibited code-switching.

As Major (2010) notes, there is a relative lack of research into the L1 attrition of perception. Despite the smaller body of work, the trend seems to indicate that perception is also vulnerable to attrition. Ventureyra, Pallier, and Yoo (2004) found that L1 Korean adoptees raised in France had lost the ability to perceive phonemic distinctions in stop consonants, even though a subset of the participants had lived in Korea until age 9. L1 Italian attrition has also been found in a handful of studies in the last decade. Cancila and Celata (2010) present data that point to the L1 attrition of Italian geminate consonants in the Lucchese community in San Francisco, US, while Flege, Mackay, and Meador (1999) tested L1 Italian/L2 English bilinguals in Canada on their discrimination of English and Italian vowels. Discrimination accuracy was significantly lower for the late bilinguals than the early bilinguals, indicating L1 attrition in the late bilinguals.

\textsuperscript{11} This finding contradicts Schmid (2007) and Cherciov (2011), who both find that frequency of L1 use does not reliably predict degree of attrition.
In the only known study to investigate attrition in the perception of foreign accent, Major (2010) investigated the perception of BP accent by native and non-native speakers of BP. Foreign accent ratings by L1 BP judges living in the US differed significantly from those of L1 BP judges living in Brazil, leading Major to suggest attrition in the L1 BP speakers in the US and to posit that country of residence is a determining factor in L1 attrition, rather than frequency of use.

**Predictions for the PPH.** Taking into account the research reviewed in this section, two general predictions can be made. First, it is reasonable to predict that the L1 Spanish speakers (successive and simultaneous bilinguals alike) will have evidenced attrition in their Spanish phonological system prior to exposure to L3 BP, as a consequence of consistent exposure to L2 English independent of environment. To address this, the experimental participants that are early acquirers of Spanish will be compared with bilinguals with a similar profile that have not been exposed to BP as an L3 (see Chapter 4 for details). The second general prediction is that exposure to BP as an L3 will lead to attrition of the Spanish system across the experimental groups. This prediction is made based on the idea that if an early-acquired system is vulnerable to attrition, any existing phonological system should be vulnerable. However, this prediction is made more cautiously, given the profile of the experimental participants. Such caution stems from the fact that research reported on in the previous section is based on the L1 of speakers that have been exposed to an L2 for a minimum of 7 years, and some speakers have been living in an L2 context for more than 35 years. The experimental participants tested here range from 11 weeks to 3 years in length of BP exposure. Because there is no conclusive evidence regarding the amount or length of exposure necessary for attrition to occur, it is not certain that the length of
BP exposure here is sufficient to induce modification of early-acquired or late-acquired Spanish phonological systems.

In addition to these general predictions, two predictions can be made for the specific effects an L3 might have on native and non-native phonological systems. The first prediction, based on Major’s (2010) findings, is that L3 BP learners will demonstrate a higher degree of Spanish attrition in an immersion context than learners in a context where BP is not the dominant language. As discussed in Chapter 4, approximately half (51%) of the experimental data were collected in Brazil, so this a testable prediction given that there was an even distribution of data collected in Brazil vs. the US, and one of the independent variables measured was linguistic context. The second prediction, based on Major (1992), is that BP proficiency will affect the degree of Spanish attrition. As described in detail in Chapter 4, a cross-sectional investigation of BP learners at two levels of proficiency (intermediate and advanced) was carried out, allowing for examination of L3 proficiency as a variable.

While the existing L1 attrition research affords the possibility to make the aforementioned predictions, it does not lend itself to predictions of the comparative attrition between early- and late-acquired Spanish phonological systems. This leads to the research question at the center of this dissertation, which is whether a late-acquired Spanish phonological system is more vulnerable to influence from L3 BP than an early-acquired system.

The second issue to be addressed is how phonological attrition can be modeled within OT. Existing phonological attrition research is largely descriptive, and OT scholars have just begun addressing attrition within an OT framework (see e.g., Culberston, Smolensky, & Wilson, submitted). Two proposals for modeling the different possible outcomes in OT specific to the property under investigation will be discussed in Chapter 3.
2.5 Fundamental Differences Between an L1 and an L2?

Having framed the present study, I now turn to a detailed discussion of the PPH. First, I address the existing research related to the question that lies at the center of the study of SLA: Are L1 and L2 systems fundamentally different? I provide a general background of the idea of a critical period (CP) and the Critical Period Hypothesis (CPH) in order to establish a general working definition of the CPH. This is a necessity, given that the PPH assumes that age of acquisition is a deterministic variable in the composition of early- and late-acquired phonological systems. Second, I provide a concise review of the literature that looks at a CP for L2 phonology as an illustration of the lack of consensus in the field. Third, I detail a novel approach to the question of a fundamental difference in L2 phonological acquisition, revisiting the PPH first introduced in Chapter 1. Specifically, I operationalize a definition of a critical period as it relates specifically to the PPH and expand upon the predictions made by the hypothesis.

2.5.1 The Critical Period Hypothesis

According to Newport (2002), a CP is a maturational window of time during which some crucial experience will have its peak effect on development or learning, resulting in normal behavior attuned to the particular environment to which the organism has been exposed. If the organism is not exposed to this experience until after this time period, the same experience will have only a reduced effect, or in extreme cases may have no effect at all (Newport, 2002, p. 737). The existence of a CP is generally accepted for the acquisition of a primary language (see Curtis, 1977 for the prima facie case of Genie) and, although acknowledged as a possible partial explanation of difference by many who study adult L2 acquisition, the actual definition of a CP as applied to L2 acquisition remains contentious and a single working definition has yet to be
agreed upon. Definitions can differ in terms of the linguistic domains affected (or not),\textsuperscript{12} whether a period is critical or sensitive,\textsuperscript{13} the causes of a CP, and the onsets and offsets of a CP or multiple sensitive periods. As Singleton (2005) points out, the fact that researchers do not agree on one definition for the critical period makes it difficult to determine what a researcher might mean when s/he claims to reject or support the CPH. I will address this lack of consensus in the next section as it applies specifically to a CP for L2 phonology.

2.5.1.1 A critical period for L2 phonology

As noted, phonological success achieved by early acquirers is not guaranteed for late acquirers of a phonological system, at least not on the surface (e.g., Abrahamsson & Hyltenstam, 2009; Long, 2005; Granena & Long, 2012; Scovel, 1988, \textit{inter alia}). This undeniable difference between early- and late-acquired phonological systems is a focus of L2 phonology research and has driven the investigation of whether there are maturationally-conditioned differences between systems acquired in childhood vs. adulthood.\textsuperscript{14} While some researchers have proposed a critical or sensitive period\textsuperscript{15} for language acquisition affecting all components of the linguistic system (e.g., Abrahamsson & Hyltenstam, 2009; Granena & Long, 2012), several researchers maintain that there are critical/sensitive periods for specific linguistic modules, but not for all (or none at

\begin{itemize}
\item \textsuperscript{12} Several researchers maintain that there are critical/sensitive periods only for specific linguistic modules, or that there is no critical period for any of the linguistic modules (e.g., Rothman, 2008; Slabakova, 2006, 2008).
\item \textsuperscript{13} A sensitive period is conceived of as a gradual maturationally-conditioned decline in ability/sensitivity that culminates in effects similar to those of a critical period (see e.g., Oyama, 1976 for a discussion).
\item \textsuperscript{14} With the exception of the generative L2 phonology studies discussed in Section 2.2 that explicitly examine the development of L2 mental representations, the research in the present section does not explicitly state what, if anything, is maturationally constrained (e.g., surface output, mental representation, etc.). As such, it is difficult to make direct comparisons between the research in this section and CP research in generative L2 phonology. That being said, it is necessary to review the history of this line of inquiry.
\item \textsuperscript{15} Henceforth, I conflate the terms critical and sensitive periods, except where noted by another author’s work. Although there are important conceptual differences, they do not enter into the present study. Therefore, these distinctions are not relevant.
\end{itemize}
all, as is the case in Rothman, 2008). More than 50 years ago, Dunkel and Pillet (1957) reported that only phonetics and phonology were subject to a critical period, an observation echoed in later research by Fathman (1975), Fathman and Precup (1983), and Scovel (1988), among others.

In his seminal work, Scovel (1988) claimed pronunciation to be the sole linguistic capacity to show age effects, due to its neuromuscular basis, and that pronunciation was fundamentally different from other areas, such as syntax, because the latter lack a “physical reality” (Scovel, 1988, p. 101). In the last 25 years, there has been a large body of research presenting evidence both in favor of and against a CP for phonology.

Remembering Long’s (2005) and Rothman’s (2008) can-versus-cannot dichotomy (see section 1.1) that a single learner that can stand up to careful linguistic scrutiny and still come out as nativelike should be enough to falsify the CPH, there is in fact ample research that meets this criterion. In Moyer’s (1999) study of L1 English/L2 German learners, one of 24 speakers was judged as native in a free speech task. In a study by Birdsong (2007) of L1 English/L2 French speakers, two of 17 speakers were judged as native with respect to production of voice onset time, vowel length, and global pronunciation. Acoustic analysis of three phonetic properties of Spanish stop-liquid clusters in a study by Colantoni and Steele (2006) revealed that one of five advanced L2 Spanish speakers tested as native-like.17

Despite the evidence that does not support a CP for phonology in the aforementioned studies, Abrahamsson and Hyltenstam (2009) call the evidence against a CP an “overestimation of the incidence of nativelikeness” (2009, p. 259). This is in part due to a lack of what they call a

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16 Given the focus on mental representations that are at the heart of generative SLA and specifically the PPH, it is important to note that Scovel presents effects of a CP for L2 phonology in terms of surface production, making no claims about mental representations.

17 While acoustic analysis allows for a more objective, fine-grained look into the phonetic representations of an L2 system, the authors do not address the relationship between these phonetic representations and underlying phonological representations.
“specified understanding of the concept of nativelikeness” (pp. 258-259). While several studies are carried out under the assumption that nativelikeness is something that can be 1) self-identified (e.g., Piller, 2002) or 2) perceived by others (e.g., Moyer, 1999), Abrahamsson and Hyltenstam also subscribe to a third interpretation, which is that nativelikeness is to be a native-like speaker in terms of linguistic competence and performance. This third interpretation (referred to by Granena and Long, 2012, p. 7 as ‘scrutinized’ performance, as opposed to ‘perceived’ performance) is defined via acoustic measurement of carefully controlled linguistic production and perception of auditory stimuli, although they cover all three interpretations in the study. All of their participants importantly identify themselves as native-like speakers of L2 Swedish (interpretation 1), and native speaker judges are used to assess the learners’ global proficiency via analysis of recorded speech samples (interpretation 2). From the native speaker assessments, a subset of the participant pool was selected for further testing to see if they qualify as native-like speakers in terms of interpretation 3. Of the 104 L2 Swedish speakers that submitted speech samples, a subset of 41 speakers were judged as native-like, and completed a battery of 20 linguistic tasks. Of the 10 tasks reported on in the article, four tasks tested phonological nativelikeness. Based on performance on production and perception tasks with regard to voice onset time (VOT) and speech perception in noise, none of the 41 speakers with an age of acquisition over eight years performed within the native speaker range for all of the instruments that tested phonology. While the authors do not specify a CP for phonology, choosing instead to focus on a CP for global nativelikeness, it might be inferred from their data that the CP for phonology has a cutoff of approximately eight years of age. This particular CP falls in line with evidence from Long (2005) and Granena and Long (2012), which report an early sensitive period for phonology between the ages of six and 12.\(^\text{18}\)

\(^\text{18}\) It is of note that the data from these studies, while resulting from controlled laboratory experiments, make it
Given this contentious background for the notion of a CP for phonology, it is important to articulate a working definition for both the CP and CPH for the present study since age of acquisition is assumed here to be a determining factor in phonological acquisition. As such, a simple conception of a CP has been adopted here in order to make testable predictions: A critical period is the period of time before the age of twelve years (Lenneberg, 1967). This CP will be applied to the phonological component of a linguistic system, making no assumptions about other linguistic modules. With a working definition of a CP for phonological acquisition established, the next section presents the PPH in finer detail, discussing the testable predictions that derive from the hypothesis and possible outcomes.

2.5.1.2 The Phonological Permeability Hypothesis

The PPH states that there is a maturationally-conditioned fundamental difference between phonological systems acquired before vs. after the age of 12 years. However, rather than considering this fundamental difference in terms of access to UG, the PPH posits such a difference to be related to stability. That is, the mental representation of a late-acquired phonological system is predicted to be significantly more vulnerable to influence from a novel L3 system than an early-acquired system. Based on limited pilot data presented in Cabrelli Amaro and Rothman (2010), this is the strong version of the hypothesis. Testing the hypothesis via investigation of groups of English/Spanish bilinguals who differ with respect to the age and context of acquisition of Spanish, there are several possible outcomes when comparing early and late acquirers of Spanish.
**Possible outcome 1.** In comparing the Spanish phonological systems of early and late acquirers, one possible result is that there will be no statistically significant differences between groups in either the perception or production data. In such a case, there is no indication of differential stability between L1 and L2 Spanish speakers, and therefore the PPH would not be supported.

In such a case, the comparison of the L3 BP learners’ Spanish perception and production data with the Spanish control data will be of interest. Regardless of the outcome of the experimental group comparisons, comparing the experimental and control data will importantly inform whether there are changes to Spanish mental representations in general due to L3 BP influence, contributing to the body of phonological attrition research.

**Possible outcome 2.** A second potential outcome is that both the perception and production data will yield statistically significant differences between the groups of early and late acquirers, indicative of a higher degree of instability of the Spanish mental representation among the late acquirers. Such an outcome would support the PPH.

**Possible outcome 3.** A third possibility is that there will be no statistically significant differences in the L1 and L2 Spanish perception data, but there will be differences across the groups’ production data. Such an asymmetry could conceivably suggest that while the stability of the phonological representation is comparable for early and late acquirers, production differences might be the result of processing issues in terms of inhibitory control, i.e., the (in)ability to suppress the BP system during Spanish production. While such data does not support the PPH in its strong form, there would be support of differences in terms of stability, albeit at the level of processing. Should this outcome be realized, I will revisit the possibility of a weak version of the PPH.
2.6 Summary

This chapter has served as a broad overview of the different theoretical assumptions relevant to the present study. After a review of the development of the field L2 generative phonology and proposing OT as the most descriptively and explanatorily adequate framework for this study, pertinent literature in the areas of L3 phonology and phonological attrition was reported on and predictions were made for this project that result from established research in these areas. Finally, the general predictions were presented that are borne out of the PPH. Having laid the theoretical foundation and the broad predictions for the PPH here in Chapter 2, Chapter 3 serves as an introduction to vowel reduction, the phenomenon under investigation in the current study, designed to test the PPH. After describing the phenomenon and how it presents (or does not) in BP, Spanish, and English, an OT analysis of vowel reduction is proposed, and the L3 learning task and potential attrition within OT are modeled.
Table 2-1. Sample tableau

<table>
<thead>
<tr>
<th>/input/</th>
<th>CONSTRAINT 1</th>
<th>CONSTRAINT 2</th>
<th>CONSTRAINT 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Candidate A</td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Candidate B</td>
<td></td>
<td>*</td>
<td>*!</td>
</tr>
<tr>
<td>Candidate C</td>
<td></td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>
3.1 Overview

This chapter is dedicated to the phenomenon that I have investigated to test the Phonological Permeability Hypothesis. The discussion in Chapter 2 demonstrated how Optimality Theory can account for a dynamic phonological system. Given the aims of this project, I employ an OT framework to describe the acquisition of a novel phonological system in terms of full transfer of L1 constraints and subsequent reranking via exposure to L2 input and universals. Additionally, I use OT to model the modification of an existing system via the same algorithm used for acquisition, as well as to explain how and why a nonnative system might modify in a different way than a native system. In the present chapter, I first introduce the phenomenon of vowel reduction, describe the surface output of word-final unstressed vowels and present an Optimality Theoretic analysis in Spanish, BP, and English, respectively. Once the relevant constraints and rankings have been laid out, I discuss the L3 learning task. Finally, I present tentative predictions borne out of the PPH in terms of differential regressive influence and model them in the form of potential constraint reranking.

3.2 Vowel Reduction

Vowel reduction is a change or changes in the acoustic quality of a vowel that is perceived as weakening and can be conditioned by a change in stress, sonority, duration, loudness, or articulation. Vowel reduction occurs in BP and English but does not occur in the great majority of Spanish dialects. However, vowel reduction has been observed in Central Mexican Spanish when a vowel is in contact with /s/ (e.g. Cotton & Sharp, 1988), and in Andean Spanish mid vowels (Delforge, 2008; Lipski, 1990). Delforge found vowel devoicing in the Spanish of Cuzco, Peru to be the most common form of reduction and elision the least common, while Lipski presented evidence of vowel shortening, devoicing, and deletion in Ecuadorian Spanish. According to the language background questionnaires, none of the participants (experimental or control) were speakers of either of these dialects of Spanish. Moreover, none of the experimental trials contained vowels in contact with /s/.
between languages that exhibit reduction (e.g., BP and English) and those that do not (e.g., Spanish) is a question of linguistic rhythm. Languages are considered to be on a rhythm continuum with stress-timed rhythms on one end and syllable-timed rhythms at the other.\footnote{Originally, arguments of isochrony requirements (that is, requirements on the division of time in equal parts) motivated strict categorizations of syllable-timed, stress-timed, or mora-timed, depending on whether rhythm is based at the level of the foot, syllable, or mora, respectively (e.g. Abercrombie, 1967; Ladefoged, 1975; Pike, 1945). However, empirical research (e.g. Dauer, 1983; den Os, 1988) has failed to support these arguments. More recent research (see Nespor, Shukla, & Mehler, 2011 for a review) supports that the acoustic correlates of rhythm are the percent of an utterance occupied by vowels and the standard deviation of consonantal intervals.} In a language such as Spanish that falls at the syllable-timed end of the continuum, syllables are thought to be equally prominent in terms of duration and/or intensity regardless of stress, and therefore such languages lack reduced vowels. On the other hand, for languages that place closer to the stress-timed end of the continuum such as English or BP, vowel reduction is prominent.

3.2.1 BP

3.2.1.1 The BP vowel inventory and stress

In BP, primary stress is restricted to a three-syllable window at the right side of the word, yielding words with ultimate, penultimate, and antepenultimate stress (Bisol, 1992). Among the three possible accent patterns, penultimate stress is the most frequent. Stress in BP has phonetic correlates of duration and intensity, with the stressed syllables having longer duration and higher intensity than unstressed syllables in a polysyllabic word (e.g. Massini-Cagliari, 1992). Therefore, in a word like cavalo [kɐ.'va.lo] ‘horse’, the syllable [va] will be the longest syllable in the word and have the highest intensity.

The description of the BP vowel system I provide here addresses the phonetic output, rather than the phonological input. This is due to a fundamental principle of OT, known as richness of the base (ROTB). The assumption of ROTB is that the set of possible inputs is universal, and a language’s inventory consists of the outputs yielded by the grammar when it is fed this set of inputs (Prince & Smolensky, 1993[2004]). Therefore, throughout this dissertation,
I will focus on phonetic outputs, except in the case that there is a need to motivate the inputs that I present in the tableaux.

In stressed position, the vowel inventory is [i e a ɔ o u], and in unstressed position, the number of contrastive vowels reduces in accordance with the grade of weakening of the syllable. In pre-tonic and post-tonic non-final syllables, there is a five-syllable inventory [i e a o u]. However, certain contrasts are unstable. In pre-tonic position, [e] often alternates with reduced [ɪ] and [o] alternates with reduced [ʊ], with non-reduced outputs evident in citation speech.

(1) BP pre-tonic mid-high vocalic alternations
a. [e] ~ [ɪ]  *emenda*  [e.ˈmẽ.ɐ] ~ [ɪ.ˈmẽ.ɐ]  ‘amendment’
b. [o] ~ [ʊ]  *comando*  [ko.ˈmẽ.ɐ] ~ [ko.ˈmẽ.ɐ]  ‘lead’
This is especially common in pre-tonic syllables that precede a syllable with a high vowel, due to vowel harmony.
c. [e] ~ [ɪ]  *menino*  [me.ˈni.nɐ] ~ [mi.ˈni.nɐ]  ‘boy’
d. [o] ~ [ʊ]  *bonito*  [ˈbo.ni.tʊ] ~ [ˈbo.ɐ.ni.tʊ]  ‘pretty (masculine)’

In post-tonic non-final syllables (which occur only in words with antepenultimate stress), the vowel inventory is also [i e a o u], and the mid-high vowel contrasts are also unstable. Additionally, the low vowel is realized as a weak [a] or a reduced [ɐ].

(2) BP unstressed post-tonic non-final vocalic alternations
a. [e] ~ [ɪ]  *pêssego*  [ˈpe.se.go] ~ [ˈpe.si.go]  ‘peach’
b. [o] ~ [ʊ]  *cômodo*  [ˈko.mo.do] ~ [ˈko.ʊ.mo.do]  ‘room’
c. [a] ~ [ɐ]  *cágado*  [ˈka.gɐ.do] ~ [ˈka.ɐ.do]  ‘turtle’

Post-tonic final syllables are the weakest, and have the smallest vowel inventory, [ɐ, i, ʊ] (Barbosa & Albano, 2004). This syllable position will be the focus of the present study.
(3) BP unstressed word-final vowel reduction

a. \[v\]
   \[casa \ ['ka.zə]\] ‘house’
   \[vaca \ ['va.kə]\] ‘cow’

b. \[i\]
   \[padre \ ['pa.dɾɪ]\] ‘priest’
   \[frase \ ['fra.zə]\] ‘phrase’

c. \[o\]
   \[libro \ ['li.bɾʊ]\] ‘book’
   \[parto \ ['par.tɔ]\] ‘birth’

As a summary, Figure 3-1 illustrates the phonetic vowel inventory according to syllable position.

3.2.1.2 Theoretical analysis

Crosslinguistically, vowels in unstressed position undergo qualitative changes in a wide variety of ways. While a single formal analysis of vowel reduction is the goal of any analysis based on Universal Grammar (UG) constraints, Crosswhite (2001, 2004) proposes that vowel reduction is a phenomenon that happens for one of two reasons, and these motivations for reduction create a paradox. Reduction can occur to enhance contrast by avoiding nonperipheral vowels in non-prominent positions (e.g. Belorussian), or to reduce sonority in non-prominent positions (e.g. BP in post-tonic position).

Reduction driven by contrast enhancement. Belorussian is an example of a language that avoids non-corner vowels in unstressed position to enhance contrast, whereby mid vowels /e, o/ reduce to peripheral [a].
(4) Belorussian vowel reduction

a. /e/  [ˈre.ki] ‘rivers’  [ra.ˈka] ‘river’

b. /o/  [ˈno.yi] ‘legs’  [na.ˈya] ‘leg’

This type of reduction is spurred by a desire to avoid ineffectual articulation in an environment in which a particular feature’s acoustic cues are absent or reduced. According to Crosswhite (2001, 2004), contrast enhancement is motivated by the facts that noncorner vowels are subject to misperception and stressed position enhances correct perception of noncorner vowels. Contrast enhancement is modeled by Crosswhite in OT via ranking of Licensing constraints that yield reduced vocalic outputs, and the constraint that she posits to motivate most cases of contrast-enhancing vowel reduction is ḺIC-Noncorner/Stress.

(5) ḺIC-Noncorner/Stress:

Noncorner vowels are licensed only in stressed positions.

When this constraint outranks relevant vowel faithfulness constraints (in the case of Belorussian, MAX[round], MAX[+front]) and MAX[-high] is also undominated, unstressed mid vowels in the input will surface as [a] in the output (Table 3-1).

Reduction driven by prominence reduction. While BP vowel reduction in pre-tonic position is a result of contrast enhancement (Crosswhite 2001, 2004), reduction in post-tonic position is a result of prominence reduction. As mentioned, for the purpose of this study I will focus only on post-tonic final vowel reduction.

In BP, post-tonic final reduction occurs to reduce prominence in unstressed position, in which prominence corresponds to sonority. Sonority reduction in BP is not a simple case of elimination of more sonorous low and mid vowels, as evidenced by the presence of non-high
vowel [e] in word-final position. The inventory in word-final position [i o e] comprises a class of low-sonority reduced vowels, and BP prominence reduction can be modeled with the family of prominence reduction constraints.  

In prominence alignment, segmental sonority is correlated with prominence such that prominence at two levels should coincide. Therefore, a prominent feature or segment should not occur in a non-prominent environment, and vice versa. Prince and Smolensky (1993 [2004]) originally formalized this concept with two phonetic scales to capture the relationship between segmental sonority and syllable position, in which Scale 1 describes syllable prominence, demonstrating that a peak syllable position is more prominent than a margin syllable position. Scale 2 shows the hierarchy of segmental prominence. The symbol ‘prom’ indicates ‘is more prominent than’.

Parker (2008) posits an exhaustive sonority scale for English, Spanish, and Quechua in which peripheral vowels are more sonorous than central vowels. Within each of these classes, height determines sonority relationships. Given this, lower vowels are more sonorous. The higher end of his sonority scale then looks like this:

(6) Relative sonority of vowels

$\text{low} \text{prom} > \text{mid peripheral} \text{prom} > \text{high peripheral} \text{prom} > \text{mid interior} \text{prom} > \text{high interior} \text{prom}$

But cf. Crosswhite (2001, 2004), who reports that the surface vowel inventory in post-tonic final position consists of [ə i u].

Crosswhite (2001, 2004) notes that the idea of prominence reduction and the sonority hierarchy is phonetically motivated. Several acoustic correlates have been proposed. Malsh and Fulcher (1989) posit that the correlate is a combination of intensity and jaw opening, and Crosswhite (2001, 2004) cites work (Johnson, 1980; Keating, 1983; Stevens, 1986) that posits low-frequency amplitude as a correlate, noting how it might account for vocal prominence. Most recently, Parker (2008) found an overall mean Spearman’s correlation of .91 between sonority indices and intensity values for all the phonemes in English, Spanish, and Quechua. He concludes that sonority can thus be characterized based on intensity via linear regression. Crosswhite also notes that the relative sonority of vowels (and sonorant consonants) is more straightforward than that of obstruents and there is a vowel height-duration correlation (see e.g. Lehiste, 1970). In Chapter 4, a detailed description of the phonetic correlates measured to test the predictions presented in this chapter is provided.
Additionally, reduced vowels are less sonorous than full vowels, and therefore they appear lower on the scale than a full high interior vowel, for example. However, as shown by BP, pre-tonic contrast enhancement is evidence that there is a difference between the mid-high peripheral vowels /e, o/ and mid peripheral vowels /ɛ, ɔ/, creating the need for a more detailed sonority scale. Taking Barbosa and Albano’s (2004) phonetic inventory of BP vowels into account in conjunction with a slightly modified version of Parker’s (2008) scale of relative sonority, I propose the following relationship between accentual prominence and sonority:

(7) Prominency scales

Scale 1: Accentual prominence

\[\text{stressed}^{\text{prom}} > \text{unstressed}\]

Scale 2: BP vocalic prominence (sonority)$^5$

\[a^{\text{prom}} > \varepsilon, \sigma^{\text{prom}} > e, o^{\text{prom}} > i, u^{\text{prom}} > (\varepsilon)^{\text{prom}} > (i, u)^{\text{prom}}\]

When crossing the two scales by taking an element from the first scale along with an element from the second scale, the result is a combination that will form the basis of the OT constraints that militate against that particular pair of elements. These constraints are ranked against one another, and reflect the order of elements in scale 2. Constraints are produced that focus on either the stressed (prominent), or the unstressed (non-prominent), the two members of Scale 1. Effects of the \(*\text{UNSTRESSED}\) constraint hierarchy are found in many languages with vowel reduction that is spurred by prominence reduction. The constraints occur in decreasing order of sonority and militate against sonorous sounds in unstressed position; they are referred to as a prominence reduction family (Crosswhite, 2001, 2004; Jiang-King, 1996). On the other hand, the \(*\text{STRESSED}\) constraints are in increasing order of sonority and show that prominence is

---

$^5$ Phonetically reduced vowels are indicated throughout by parentheses.
Post-tonic final vowel reduction in BP is similar to the case of Bulgarian vowel reduction detailed in Crosswhite (2001, 2004), and can be explained by the interaction of the *UNSTRESSED/X constraint family with faithfulness constraints related to [round], [front] and [high] features.\(^6\) In BP, I will assume here that the inputs for the vowel inventory are /a e o/. These inputs have been selected based on evidence from careful, exaggerated speech in BP. Taking these inputs into account in the case of BP vowel reduction, *MID and Max[+LOW] are thus violated to yield [ɐ], while violations of Max[-HIGH] and Dep[+HIGH] yield [ɪ ʊ]. Consistent with Crosswhite’s analysis, the constraint ranking consists of two strata, in which all of the constraints in stratum 1 outrank all of the constraints in stratum 2.\(^7\)

\[(8) \text{BP constraint ranking}\]

\text{Stratum 1: Max[+FRONT], Max[-FRONT], Max[ROUND], Max[-LOW], Max[+HIGH], Dep[-FRONT], Dep[ROUND], Dep[+LOW], Dep[-LOW], Dep[-HIGH], *UNSTRESSED/a, *UNSTRESSED/ɛ, ɔ, *Unstressed/e, o, *Unstressed/i, u}\]

\text{Stratum 2: *UNSTRESSED/b, *UNSTRESSED/ɪ, o, Max[-HIGH], Dep[+HIGH], *MID, Max[+LOW]}

Crosswhite assumes that the rest of the Max[F] and Dep[F] constraints are undominated and thus those relevant features will always be maintained by a segment. Undominated Max[ROUND]

---

\(^6\) The same articulatory feature specifications used in Crosswhite (2001) are used here, as Crosswhite notes that it is adequate for the purpose of vowel reduction since it allows reference to natural vowel classes. However, based on Crosswhite (2004) it is possible that these constraints need to be revised. According to Flemming (2004), since articulatory tongue movement does not occur, it might be that the articulatory constraints are actually undominated. Instead, it could be that acoustic constraints are being violated. For example, Max [+high F1], rather than Max [-high].

\(^7\) As will be seen across the analyses of each of the three languages relevant to this project, the division of strata work for each individual analysis. However, once the inventories from the three languages are combined, a more fine-grained analysis of the rankings will be necessary.
crucially prevents input /o/ from surfacing as [ɪ] and input /e/ from surfacing as [ʊ]. MAX [+FRONT] prevents input /a/ from surfacing as [ɪ]. *UNSTRESSED/a is also undominated, which means that [a] in unstressed position will never surface in BP. Similarly, *UNSTRESSED/e, ɔ, *UNSTRESSED/e, ɔ, and *UNSTRESSED/i, u are virtually undominated, because only *UNSTRESSED/a is above them and therefore it is likely that none of these vowels will surface in unstressed final position. MAX [-HIGH] will always be violated by the optimal candidate, thus its low ranking. The tableaux in Tables 3-2, 3-3, and 3-4 illustrate the constraint hierarchy that yields the BP surface inventory of vowels in word-final position.

3.2.2 Spanish

3.2.2.1 The Spanish vowel inventory and stress

Unlike BP and English, Spanish does not evidence vowel reduction and maintains an inventory of five full vowels (Figure 3-2) independent of stress. Compare the word-final unstressed outputs in (3) for the BP words casa ‘house’, padre ‘priest’, and libro ‘book’ with the Spanish outputs in (9).

(9) Spanish unstressed word-final vowels
   a. [a] casa ['ka.sa] ‘house’
   b. [e] padre ['pa.dɾe] ‘priest’

The difference between BP and Spanish seems to be that Spanish is a strictly syllable-timed language and with a relatively low correlation of stress with duration, while Major (1992) presents acoustic evidence that BP post-tonic syllables undergo greater shortening than pre-tonic syllables, and suggests that post-tonic syllables in BP are stress-timed whereas pre-tonic syllables are syllable-timed. The pattern of sonority-decreasing vowel reduction in post-tonic position amplifies the effect of post-tonic shortening.
3.2.2.2 Theoretical analysis

Given the lack of vowel reduction in most dialects of syllable-timed Spanish, the full set of feature faithfulness constraints related to the five-vowel [a e i o u] inventory are undominated with the exception of *MID, and the family of prominence reduction constraints relevant to full vowels are ranked below the feature constraints in a second stratum. As modeled in the tableaux in Tables 3-5, 3-6, and 3-7, the result is an inventory in which vowels are fully realized, regardless of stress.

(10) Spanish vocalic prominence scale

\[ a_{prom} > e, \; o_{prom} > i, \; u_{prom} \]

(11) Constraint ranking - Spanish vowels

Stratum 1: MAX[+FRONT], MAX[-FRONT], MAX[ROUND], MAX[-LOW], MAX[+HIGH], DEP[-FRONT], DEP[ROUND], DEP[+LOW], DEP[-LOW], DEP[-HIGH], MAX[-HIGH], DEP[+HIGH], MAX[+LOW]

Stratum 2: *MID, *UNSTRESSED/a, *UNSTRESSED/e, o, *UNSTRESSED/i, u

3.2.3 English

3.2.3.1 The English vowel inventory and stress

A growing body of research provides evidence in favor of psychotypologically-based transfer of Spanish to BP (see e.g. Cabrelli Amaro et al., 2009; Cabrelli Amaro, in press; Giancaspro & Halloran, in press; Montrul et al., 2011), which leads to the prediction that the learners’ Spanish rankings will transfer at the initial stages of L3 BP. However, it is a legitimate possibility that the English rankings could transfer in addition to or instead of Spanish. As such, it is necessary to turn the discussion to word-final vowel reduction in English.
The standard American English stressed vowel system consists of 11 monophthongs, illustrated in Figure 3-3. In English, vowel reduction is conditioned by both stress and syllable structure (that is, whether the syllable is open or closed). According to Hayes (1995), the word-final unstressed vowel inventory is limited to /i o ə/. However, there are two issues with this assessment. First, there is no distributional evidence that a rhotic vowel is part of the group of word-final vowels (see Footnote 7). Second, there is evidence from Spanish loanwords such as alpaca and banana that the American English output [ə] in word-final position corresponds to an input of /a/. Taking these data into account for the purpose of determining the vocalic inputs in word-final position, I propose that the inputs in word-final unstressed position are /i o ɑ/. All three of the word-final vowels are phonetically reduced in the output. Assuming the aforementioned inputs, the peripheral vowel inputs are centralized in order to reduce prominence: High front /i/ surfaces as [i] (Kreidler 2004; McCully 2009; Roach 2009), mid-high back /o/ surfaces as [o] (Bolinger 1989), and low back /a/ surfaces as [ə] (Figure 3-4).

8 Adapted from The Language Samples Project (2001). The chart has been amended in the following ways: 1) /a/ is used instead of /a/; 2) only the stressed vowel inventory is represented. Several accounts of the English vowel system (e.g. Ladefoged 1999) include a rhotic mid central vowel /r/ to describe the stressed vowel in a word like turkey [ˈtʰ ru.ˌkɪ]. In unstressed position, the surface output is posited to be [ə]. However, the idea of a rhotic vowel is very ambiguous in phonological theory, in that it is not certain if the sound is a sequence of a central vowel plus a rhotic consonant, a rhotacized vowel, or a syllabic /r/. Given a lack of compelling distributional evidence to include /r/ as a primitive of the vowel set, it is assumed here that the rhyme of the initial syllable in turkey has an input/output of /ˈtʰə.ˌkɪ/ ~ [ə]. In unstressed position as in the word letter, the input/output is assumed to be /ˈlə.ˌtɛ/ ~ [ə]. Closed syllables are outside of the scope if this project.

9 While /u/ appears word-finally in what might appear to be unstressed position (e.g. into), Flemming and Johnson (2007) posit that word-final /u/ bears at least secondary stress. They base this conclusion on an informal poll carried out by Steriade (personal communication), which evidences a lack of flapping in the word-final syllable /tu/ in American English. As can be seen in examples 11a-d (feta, butter, kitty, lotto) /h/ is flapped when co-articulated with any of the three sounds in the English word-final unstressed vowel inventory assumed in this study. However, in a word such as into, /h/ is aspirated, rather than flapped. Since aspiration is conditioned by stress, it is concluded that word-final /h/ is not in fact unstressed. This argument can be expanded to include /ɛ/ in final position (e.g. Monday, waylay). Applying Steriade's flapping test to loanwords from languages that do not reduce final unstressed /e/, such as latte 'milk' (Italian) and mate 'tea' (Spanish), underlying /t/ surfaces as aspirated [tʰ] (ˈlɑ.ˌtɛɪ], [ma.tʰɛɪ].

10 Hayes (1995) represents the phoneme /o/ as /oʊ/. Here, the more traditional representation of /o/ has been chosen, and it is noted that the surface output is [oʊ]. The same applies to /ɛ/, which is commonly represented as /ɛ/, and has a surface output of [ɛ].
(12) English word-final vowel reduction

a. [i]

   *happy* [ˈhæ.pi]
   *kitty* [ˈkɪti]

b. [o]

   *widow* [ˈwɪ.ɾʊ]
   *lotto* [ˈlɑ.ɾʊ]

c. [ɔ]

   *llama* [ˈla.mɔ]
   *feta* [ˈfe.ɾɔ]

3.2.3.2 Theoretical analysis

While this is a case motivated by prominence reduction, like BP post-tonic vowel reduction, the ranking of the featural faithfulness constraints lead to a different output. Therefore, the *UNSTRESSED/X constraints and their interaction with faithfulness constraints related to [round], [front], and [high] features presented in the BP analysis must be revised for English. First, the *UNSTRESSED/X constraint family must be expanded to accommodate the English vowel inventory. According to Parker (2008), the inventory has the following relative sonority ranking:

(13) English vocalic prominence scale (sonority) (adapted from Parker 2008)

\[ \ae, \alpha_{prom} > \epsilon, \varepsilon, \lambda, \sigma, \sigma_{prom} > \iota, \iota, \sigma_{prom} > (\sigma, \sigma)_{prom} > (\iota)_{prom} \]

Remember that Crosswhite (2001, 2004) proposes that [ɛ ɔ] are more sonorous than [o e]. It is thus possible that the scale posited by Parker can (and should) be more fine-grained. Unfortunately, he only presents mean intensity differences for groups of vowels that have been ranked in terms of sonority from phonological (and not acoustic) evidence. However, it is
possible to refine the constraints based on the scale for which he reports ample evidence for: low 
\( \text{prom}_\text{low} > \text{mid peripheral}_\text{prom} > \text{high peripheral}_\text{prom} > \text{mid interior}_\text{prom} > \text{high interior}_\text{prom} \). Following the scale and referencing the vowel chart in Figure 3-3, I propose the following English vocalic prominence scale:  

\[(14) \text{English vocalic prominence scale} \]

\[ \ae, \text{a}_\text{prom} > \epsilon, \text{\capi}{\text{a}}, \text{\capi}{\text{e}}, \text{\capi}{\text{o}}_\text{prom} > \text{i}, \text{\capi}{\text{u}}_\text{prom} > (\text{\capi}{\text{a}}, \text{\capi}{\text{o}})_\text{prom} > (\text{i})_\text{prom} \]

Given that reduced vowels are less sonorous than full vowels, the reduced output segments (indicated by parentheses) are at the bottom of the scale and follow the scale for full vowels. As such, crossing the sonority scale with the prominence scale, *\text{UNSTRESSED}/(\text{\capi}{\text{a}}, \text{\capi}{\text{o}}) >> *\text{UNSTRESSED}/(\text{i}) will be the lowest ranked of the constraint family.

Having established the vocalic prominence scale for English, we can now turn to the featural identity constraints. As seen in Tables 3-8, 3-9, and 3-10, \text{MAX}[\text{round}] must continue to be undominated by any of the *\text{UNSTRESSED} rankings, preventing /\text{a}/ from surfacing as [\text{\capi}{\text{a}}]. However, unlike in BP, \text{MAX}[+\text{front}] and \text{DEP}[-\text{front}] will be ranked low, since they must be violated to yield [\text{i}]. *\text{\capi{MID}} will also be violated in order for [\text{\capi}{\text{a}}] and [\text{\capi}{\text{o}}] to win, and \text{MAX}[+\text{low}] and \text{DEP}[-\text{ow}] will also be violated for [\text{\capi}{\text{a}}] to win.

\[(15) \text{Constraint ranking - American English word-final unstressed vowels} \]

\text{Stratum 1:} \text{MAX}[-\text{FRONT}], \text{MAX}[\text{ROUND}], \text{MAX}[-\text{LOW}], \text{MAX}[+\text{HIGH}], \text{MAX}[-\text{HIGH}], \text{DEP}[+\text{HIGH}], \text{DEP}[-\text{HIGH}], \text{DEP}[+\text{FRONT}], \text{DEP}[\text{ROUND}], \text{DEP}[+\text{LOW}], *\text{UNSTRESSED}/\text{\capi{a},\ae} *\text{UNSTRESSED}/\epsilon,\text{\capi{\text{a}},\text{\capi{\text{e}}}}, *\text{UNSTRESSED}/\text{\capi{\text{e}},\text{\capi{\text{o}}}}, *\text{UNSTRESSED}/\text{i,\text{\capi{\text{u}}}}

\text{Stratum 2:} *\text{\capi{MID}}, \text{MAX}[+\text{LOW}], \text{DEP}[-\text{LOW}], \text{MAX}[+\text{FRONT}], \text{DEP}[-\text{FRONT}],

*\text{UNSTRESSED}/(\text{\capi{\text{e}},\text{\capi{\text{a}},\text{\capi{\text{o}}}}), *\text{UNSTRESSED}/(\text{i,\text{\capi{\text{u}},\text{\capi{\text{e}}}})}

\[\text{11 Phonetically reduced vowels are denoted by parentheses.}\]
3.2.4 Universal Prominence Reduction Constraints

Considering the universal nature of constraints, the sonority constraint scale accommodates all of the vowels in the world’s languages. However, for the sake of brevity, I will adopt a scale and corresponding constraint family that incorporates the full and reduced vowel inventories of English, Spanish, and BP.

(16) Vocalic prominence scale (English, Spanish, BP)
\[
\begin{align*}
æ, \alpha, a_{prom} & > e, ə, \lambda_{prom} > e, \alpha_{prom} > i, o_{prom} > i, u_{prom} > (ε, ə, ø)_{prom} > \\
/(i, o, i)_{prom}
\end{align*}
\]

(17) Prominence reduction constraints (English, Spanish, BP)
\[
*\text{UNSTRESSED}/æ, \alpha, a, *\text{UNSTRESSED}/ɛ,ə,λ, *\text{UNSTRESSED}/e,o, *\text{UNSTRESSED}/i,o, \\
*\text{UNSTRESSED}/i,u, *\text{UNSTRESSED}/(ɛ,ə,ø), *\text{UNSTRESSED}/(i,o,i)
\]

For each language and its language-specific prominence reduction constraints, the relative ranking of the vowel feature faithfulness constraints within each stratum was not crucial and the division of reduction and faithfulness constraints across two strata generated the attested outputs for each language. However, applying the final set of constraints in (17) to each language, there is one case in which multiple winners are generated when there should only be one optimal candidate.

3.2.4.1 BP [ə] and English [ə]

While the relative ranking of feature faithfulness constraints generates the correct reduced vocalic segment in the output (e.g. undominated Max[+front] in BP prevents reduced English [i] from surfacing in place of reduced BP [ɪ]), feature faithfulness constraint interaction does not prevent BP /a/ from surfacing as [ə] and English /a/ from surfaced as [ɛ]. While a fatal
violation of undominated *(ə)\textsuperscript{12} (18) forces an output of [v] in BP, the constraint *e (19) will have to outrank *ə for [ə] to win in English.

(18) *ə: No schwa in the output
(19) *e: No [v] in the output

Adding these constraints to the tableaux in Tables 3-11 and 3-12, the right candidate now wins.

### 3.2.4.2 Final constraint rankings

The final constraint rankings for each language are presented in (20) through (22).

(20) Final constraint ranking - BP word-final unstressed vowels

**Stratum 1:** MAX[+FRONT], MAX[-FRONT], MAX[ROUND], MAX[-LOW], MAX[+HIGH],
DEP[-FRONT], DEP[ROUND], DEP[+LOW], DEP[-LOW], DEP[-HIGH], *ə, *UNSTRESSED/æ,a,
a, *UNSTRESSED/ɛ,ɔ,ʌ *UNSTRESSED/e,o, * UNSTRESSED/i,u

**Stratum 2:** MAX[-HIGH], DEP[+HIGH], *MID, MAX[+LOW], *UNSTRESSED/(e,æ,ə),
*UNSTRESSED/(ɪ,ʊ,ɨ), *e

(21) Final constraint ranking – Spanish word-final unstressed vowels

**Stratum 1:** MAX[+FRONT], MAX[-FRONT], MAX[ROUND], MAX[-LOW], MAX[+HIGH],
DEP[-FRONT], DEP[ROUND], DEP[+LOW], DEP[-LOW], DEP[-HIGH], MAX[-HIGH],
DEP[+HIGH], MAX[+LOW]

**Stratum 2:** *MID, *UNSTRESSED/æ, a, *UNSTRESSED/ɛ,ɔ,ʌ *UNSTRESSED/e,o,
*UNSTRESSED/i,u *UNSTRESSED/(e,æ,ə), *UNSTRESSED/(ɪ,ʊ,ɨ), *e, *ə

(22) Final constraint ranking – English word-final unstressed vowels

**Stratum 1:** MAX[-FRONT], MAX[ROUND], MAX[-LOW], MAX[+HIGH], MAX[-HIGH],
DEP[+HIGH], DEP[-HIGH], DEP[+FRONT], DEP[ROUND], DEP[+LOW], *e,

*UNSTRESSED/ɑ,æ,a *UNSTRESSED/ɛ,ɔ,ʌ, *UNSTRESSED/e,o, *UNSTRESSED/i,u

\textsuperscript{12} See van Oostendorp (1999) for a discussion of this constraint and the role of schwa in phonological theory.
Stratum 2: *MID, MAX[+LOW], DEP[-LOW], MAX[+FRONT], DEP[-FRONT], *U

Having established the constraint interactions that yield the word-final vowel outputs for BP, Spanish, and English, it is now possible to describe the learning task for English/Spanish bilinguals acquiring BP and to make predictions as to how potential BP regressive influence might present in the Spanish phonological system.

3.3 The L3 Learning Task and Modification of the Spanish Phonological System

The following section describes the learning task for producing word-final vowel outputs in BP, and considers predicted patterns of instability of the Spanish ranking for the different experimental groups. In this study, it is necessary to observe not only the Spanish systems of the two experimental groups, but also the acquisition of the L3 rankings associated with the phenomenon under investigation, as the learners must evidence acquisition of the BP rankings so that we can be certain that they are available for regressive transfer or interaction with existing rankings.

3.3.1 The L3 Initial State

As established in Section 2.4.1.2, existing research of L3 BP acquisition by English/Spanish bilinguals has led to the prediction that all of the experimental groups tested in this study will transfer their set of Spanish constraint rankings at the initial stages of L3 BP independent of the status of the Spanish system as an L1 (early-acquired) or L2 (late-acquired). In this case, learners will copy the Spanish ranking in (21), in which the full set of vowel feature faithfulness constraints outrank the set of prominence reduction constraints. At the BP initial
stages, fully-realized vocalic outputs are predicted, such that the input /kasa/ will have an output of [ˈka.sa], /padre/ will have an output of [ˈpa.ðɾe], and /libro/ will have an output of [ˈli.βɾo].

3.3.2 L3 Development

Given that all of the Dep[F] and Max[F] constraints outrank the family of prominence reduction constraints, the learning task for L3 BP learners that have copied their Spanish ranking at the L3 initial state therefore involves reranking of a large number of constraints from both strata. To generate the three reduced BP outputs [ɪ o ʊ], learners will have to demote four feature faithfulness constraints from Stratum 1 so that violations of the constraints will not be fatal: Max[+high], Dep[+high], *Mid, and Max[+low]. From Stratum 2, learners will have to promote *Unstressed/æ, a, a, *Unstressed/e,ɔ,ʌ, *Unstressed/e,o, and *Unstressed/i,u. Doing so will force candidates with fully-realized vowels in word-final position to incur fatal violations. Given the predictions of the GLA, I assume that there are possible stages of overlap rather than demotion by discrete steps.

It is conceivable that acquisition will occur at different rates depending on the status of the Spanish system as an L1 or L2. Given the relatively entrenched nature of an early-acquired system, it is possible that L1 Spanish learners will be slower than L2 Spanish learners to acquire BP vowel reduction (i.e., to demote relevant feature faithfulness constraints and promote relevant prominence reduction constraints). Similarly, it can be predicted that L2 Spanish learners will be comparably faster than L1 Spanish learners to demote/promote relevant constraints in BP 1) because their Spanish system is not as entrenched and 2) due to possible facilitation from their L1 English system, which exhibits a similar pattern of vowel reduction.

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13 Spanish voiced stops /b/ and /d/ surface in post-vocalic position as [β] and [ð], respectively.
3.3.3 BP > Spanish Influence

Given the dynamic nature of phonological systems, if there is modification of the Spanish system, it is possible that variation could be apparent even after partial promotion of the relevant *UNSTRESSED constraints and demotion of MAX[-high], DEP[+high], *MID, and MAX[+low] in the L3 BP system. That is, as constraints are gradually (as predicted by the GLA) reranked in L3 BP, it is possible that influence from the new L3 BP ranking could affect the Spanish system in the form of gradual changes in the relative ranking of *UNSTRESSED/æ, α, a, *UNSTRESSED/ɛ, ɔ, ʌ, *UNSTRESSED/e, o, and *UNSTRESSED/i, u, and feature faithfulness constraints MAX[-high], DEP[+high], *MID, and MAX[+low] in the Spanish system. The result of these gradual fluctuations in the ranking might be an overlap of what are crucially-ranked constraints in Spanish, which could then yield variable outputs in Spanish.

The question then becomes how this influence might specifically be modeled in OT. As noted by Putnam (personal communication, December 5, 2012), researchers have only recently begun to address issues such as the intersection of more than one set of constraints (i.e. multilingual grammars) or the weightedness of dominant grammars. Based on limited research, it seems that there are two possibilities. Assuming a modification of the mental representation of the Spanish grammar (as opposed to surface modifications resulting from issues of processing), the first possibility can be modeled within stochastic Optimality Theory as modeled by the GLA (e.g. Boersma & Hayes, 2001), which allows for a single mechanism to yield the variability that is predicted by the PPH. For reasons of economy, it would seem that the GLA, which rather convincingly accounts for acquisition, should also be able to account for attrition as it relates to modification of a phonological representation.

The second possibility is based on Goodin-Mayeda et al.’s (2011) Constraint Fluctuation Hypothesis (CFH), which is in line with Kroch’s (1994) Competing Grammar approach. The
CFH states that once learners converge on a native-like constraint ranking in the L2, learner variability can be explained by continued access to and reliance on the L1 constraint ranking. Applied here, it is possible that any attested L2 variability could be explained by learners’ reliance on L3 rankings and resulting competing grammars. Should a different outcome (i.e., ‘possible outcome 3’, see Section 2.5.1.2) be realized that indicates instability caused by issues of cognitive functions, the CFH could account for processing-induced stability. One of the aims of this project is to propose a model of native versus non-native attrition, but at this time it is possible only to posit some potential explanations. These models will be revisited after the results have been presented.

3.4 Summary

In this discussion, I have presented the phenomenon that I have observed in the Spanish and BP systems of simultaneous and successive English/Spanish bilinguals. Using the tenets of Optimality Theory, I have detailed the constraint interactions in BP, Spanish, and English that motivate each language’s word-final vocalic surface inventory, proposed the basic learning tasks involved, and considered the possibilities for the modeling of phonological instability and potential attrition. The discussion will now turn to the empirical design of the study, including the experimental participant selection, task design, and an outline of the data analysis procedures implemented.
Table 3-1. Belorussian vowel reduction.

<table>
<thead>
<tr>
<th>/tota/</th>
<th>Lic-Noncorner</th>
<th>MAX[-hi]</th>
<th>MAX[rd]</th>
<th>MAX[+fr]</th>
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<tr>
<td>[ta.ˈta]</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>[tu.ˈta]</td>
<td></td>
<td>*!</td>
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<tr>
<td>[to.ˈta]</td>
<td></td>
<td>*!</td>
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Table 3-2. BP unstressed word-final [ɪ].

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<th>MAX</th>
<th>*UNS</th>
<th>*UNS</th>
<th>*UNS</th>
<th>MAX</th>
<th>DEP</th>
<th>*Mid</th>
<th>*UNS</th>
<th>*UNS</th>
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<td>rd</td>
<td>-fr</td>
<td>a</td>
<td>e,ɔ</td>
<td>e,o</td>
<td>i,u</td>
<td>-hi</td>
<td>[+hi]</td>
<td>(e)</td>
<td>(1,ɔ)</td>
</tr>
<tr>
<td>[ˈpa.dre]</td>
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<td></td>
<td></td>
<td></td>
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<tr>
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<tr>
<td>[pa.dr(ʊ)]</td>
<td>*!</td>
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<td>[pa.dr(ə)]</td>
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Table 3-3. BP unstressed word-final [ʊ].

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<thead>
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<th>MAX</th>
<th>*UNS</th>
<th>*UNS</th>
<th>*UNS</th>
<th>MAX</th>
<th>DEP</th>
<th>*Mid</th>
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<th>*UNS</th>
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<tbody>
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<td></td>
<td>rd</td>
<td>-fr</td>
<td>a</td>
<td>e,ɔ</td>
<td>e,o</td>
<td>i,u</td>
<td>-hi</td>
<td>[+hi]</td>
<td>(e)</td>
<td>(1,ɔ)</td>
</tr>
<tr>
<td>[ˈli.vro]</td>
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Table 3-5. Spanish word final [e].

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Table 3-7. Spanish word final [a].

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Table 3-11. Revised BP word final [v].

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Table 3-12. Revised English word final [ə].

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Figure 3-1. BP vowel inventory as conditioned by stress (alternations indicated by parentheses).

Figure 3-2. Spanish vowel inventory.

Figure 3-3. Standard American English stressed vowel inventory.
Figure 3-4. Standard American English word-final phonetic vowel inventory.
CHAPTER 4
METHODOLOGY

4.1 Overview

The methodology for the present study was designed to test the acquisition of Brazilian Portuguese (BP) as an L3 by bilingual speakers of English and Spanish, and specifically to investigate potential regressive phonological influence from BP to Spanish. The Phonological Permeability Hypothesis (PPH, Cabrelli Amaro & Rothman, 2010) is tested, which maintains that adult L2 phonological systems, even when they evidence native-like target constraint rankings (assuming an Optimality Theoretic framework), are fundamentally different from native systems with regards to stability, a position that can be supported or falsified by comparing their susceptibility to cross-linguistic influence when a novel language of typological proximity is introduced as an L3.

Before detailing the methods used in this study, the research questions that are the focus of this dissertation are restated as (1, 2):

1. Is the phonological system of a non-primary language acquired after a so-called critical period more vulnerable to instability than that of a primary language?

2. What do any possible differences in L3 influence delimited by age of acquisition tell us about the nature of a phonological system acquired before vs. after a critical period?

With these research questions, and the PPH and its predictions as outlined in Chapter 2, in mind, I developed strict criteria for participation and a comprehensive proficiency assessment to facilitate participant classification. To analyze perception, production, and reaction time, a battery of tests consisting of four experimental paradigms (two of which will be reported on in this dissertation) was administered, and production data were analyzed acoustically. The remainder of this chapter describes each element of the methodology in detail.
4.2 Participants

Two of the methodological parameters subject to the most debate in the relevant literature are the selection and categorization of participants, and the use of control groups. Both of these factors are highlighted in the following sections, which describe the experimental and control groups at the center of the cross-sectional study, in addition to the longitudinal case study that facilitated the investigation of L3 BP acquisition and its influence on Spanish from its onset.

4.2.1 Experimental Groups

Given the research questions and the predictions of the PPH, it was necessary to test and compare three groups of L3 learners. Groups 1 and 2 are successive bilinguals, while Group 3 is made up of simultaneous bilinguals. Group 1 is composed of native speakers of English that acquired Spanish as an L2 after the age of 12 and have advanced Spanish proficiency (see section 4.4.2 for a detailed account of their proficiency assessment). Group 2 is made up of native speakers of Spanish raised in South or Central America that moved to the US and acquired English after the age of 12. Group 3 is composed of simultaneous bilingual speakers of English and Spanish. These learners are heritage speakers of Spanish, that is, the participants have acquired Spanish from birth in a naturalistic context, and have been raised in a community in which English, rather than Spanish, is the dominant language. All of the participants filled out a language background questionnaire (Appendix

Each group contains two subgroups: 1) Learners with intermediate BP proficiency, and 2) learners with advanced BP proficiency. Therefore, there are a total of six experimental groups. These experimental groups compose the optimal testing scenario under which the PPH can be tested: By using groups across which all three languages remain constant, the only variables that separate each group from the others are timing and context of acquisition of Spanish. Table 4-1 outlines the experimental and control groups.
While truly homogenous groups may be an impossibility given the variation among L2 and L3 learners, a number of measures were taken to control for confounding variables that fall out of such variation. The first measure was a comprehensive language background questionnaire (Appendix A). Following from studies such as those by Flege, Munro, and Mackay (1995), Mackay et al. (2006), and Flege and Mackay (2011), these questionnaires provide the necessary understanding of the learner’s language experience, particularly with respect to variables that have been found to be related to foreign accent (see Jesney, 2004, for a review of these variables). Information included age of acquisition, length of residence in English, Spanish, and BP immersion environments, formal education in each of the three languages, self-reported use (context and frequency) of the languages, as well as scalar self-ratings of reading, writing, speaking and aural comprehension. One of the most important elements of the background questionnaire that is often left out was that of other languages spoken. Potential participants with proficiency in additional languages were excluded from the study to avoid the possibility of these other languages acting as an intervening variable.

The learners who satisfied the initial requirement for participation as determined by the background questionnaire minimally had to have advanced proficiency in Spanish. Proficiency was assessed based on a two-part evaluation selected in light of existing research on proficiency assessments in L2 research. When researchers report on proficiency assessments in L2 research, they are often referring to pencil-and-paper standardized tests designed to evaluate syntax, vocabulary, and even semantics and pragmatics, without consideration of phonological proficiency. This method is interesting, considering that many L2 researchers purport that native-like phonological acquisition is less likely than native-like morphosyntactic acquisition and that acquisition in the two domains does not necessarily happen at the same rate. Other researchers
have tested various aspects of proficiency, such as White and Genesee (1996), who used an extensive background questionnaire coupled with an assessment in which trained judges evaluated elicited speech samples on an 18-point scale for pronunciation, morphology, syntax, vocabulary, fluency and overall nativeness. However, only production was evaluated. Slevc and Miyake (2006) took a different approach, administering separate evaluations of perception, production, syntax and lexical knowledge in a study that investigated the correlation between musical ability and L2 proficiency. Both studies used measures that approached a global assessment of the learners’ proficiency so as to group them in a way that was neither arbitrary nor impressionistic. While practically speaking, it was not possible to evaluate proficiency on the same scale as the two studies reviewed here, an effort to limit arbitrary and impressionistic measures was made in the present study, implementing the combination of the background questionnaire, a pencil-and-paper standardized test, and foreign accent ratings to categorize participants.

The first evaluation was a 50-item Spanish proficiency cloze test used in L2 research over the last decade (e.g. Montrul & Slabakova, 2003; Rothman & Cabrelli Amaro, 2010), administered on Survey Gizmo (see Appendix B). The second evaluation was based on a 15-second excerpt of a speech sample (Hopp & Schmid, 2013) provided at the beginning of the Spanish testing session. The excerpt was selected based on three criteria. The content: 1) had to be free of grammatical errors; 2) could not indicate that the learner was not a native speaker (e.g., the sample could not consist of a discussion of Spanish language classes); and 3) could not contain any proper nouns or code-switching. The excerpts from the experimental participants and control participants were pseudo-randomized with seven-second pauses between each excerpt, and the set of excerpts were evaluated by 16 native Spanish speakers. Judges were provided with
a spreadsheet (Appendix D) with instructions to rate a speaker’s overall foreign accent on a scale of one (very strong foreign accent) to seven (no foreign accent; definitely a native speaker). To be classified as advanced, participants had to score a minimum of 80/100\(^1\) on the Spanish proficiency test and a minimum average of four out of seven on the accent rating scale (Table 4-2). In the case that a heritage speaker’s written test score was between 60 and 79, a foreign accentedness score of four could still qualify the learner as an advanced speaker of Spanish. This exception was made because in many cases, heritage speaker bilinguals have not been formally educated in Spanish, and thus a written proficiency measurement might not be an accurate indication of proficiency.

To assess BP proficiency, participants with the equivalent of at least one semester of BP instruction also completed a two-part evaluation similar to the evaluation used for Spanish proficiency. Participants first took a 100-point proficiency test used in Rothman and Iverson (2009, 2011), administered on Survey Gizmo (Appendix C). For the second step of the evaluation, 15-second excerpts were again submitted for a scalar foreign accentedness evaluation by 11 BP native speakers (see Appendix D for spreadsheet).

As outlined in Table 4-3, participants were classified as intermediate BP speakers if they had a written test score of 60-79, and a score of between two and four on the seven-point foreign accentedness scale. Participants were classified as advanced BP speakers if they scored a minimum of 80 on the proficiency test and a minimum of four on the foreign accentedness scale. In the case of a mismatch between the written test score and speech sample evaluation, the foreign accent evaluation was used to determine proficiency given that the research questions at

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1 In the other studies in which this proficiency measurement has been used, each item is assigned a value of one point, and the maximum score is 50 points. For ease of comparison with the 100-point BP proficiency test, the maximum score has been converted to 100, with each item valuing two points.
the center of the study focus on speech production and perception, rather than syntactic and lexical knowledge.

4.2.2 Case Study

Given the variation that is characteristic of bi/multilinguals, ideally, properties should be analyzed in languages under investigation of each learner and compared against one another over time, such that the learner acts as his or her own control. Doing so informs what the learner has available for transfer from the L1 and/or the L2. When investigating regressive transfer, this method is especially important, since it is necessary to have evidence of what the learner’s systems looked like at the L3 initial state to observe any changes that occur. While logistics did not afford a longitudinal study of the full sample, the L3 acquisition of BP of one learner was investigated that fits the profile of Group 1 (i.e., L1 English/L2 Spanish). Although a sample size of one limits the generalizations that can be made from the case study results, the study was included to support (or not) any conclusions drawn from the cross-sectional investigation via comparison of the participant’s Spanish prior to and during BP acquisition.

The case study participant, referred to as Draco throughout the rest of this dissertation, began studying Spanish at the age of 14, and lived and worked in Cali, Colombia for two years at an English/Spanish dual immersion primary school. After returning from Colombia, he enrolled in an MA program in Hispanic Linguistics and taught lower-division Spanish language courses. Perception and production data were collected from Draco on two occasions. The first testing session tested Spanish only and took place prior to BP exposure, on the first day of his first BP language class in May 2012. At the time of testing, he used Spanish daily for professional and personal purposes. His written Spanish proficiency score was 92/100, his speech sample received an average rating of 6.06 out of 7.00, and his baseline testing scores were in line with those of the Spanish controls and are reported in Chapters 5 and 6. After his initial testing session, Draco
completed an intensive six-week Brazilian Portuguese for Spanish speakers course, and then participated in a six-week study abroad program in Rio de Janeiro as part of a Foreign Language Area Studies fellowship. The second testing session took place at the end of the six-week program in Rio in August 2012. This time, BP was tested first, and Spanish was tested two days later. After 11 weeks of study, Draco’s written BP proficiency score was 89/100 and his speech sample received an average rating of 4.75 out of seven, qualifying him as an advanced BP speaker according to the criteria outlined in the previous section.

4.2.3 Control Groups

Given that a full-scale longitudinal study was not possible for this project, adequate selection of a baseline measure was fundamental. In several studies (e.g. Gut, 2010; Llama, Cardoso, & Collins, 2010), L3 learners have been treated as cases of multiple monolinguals and monolingual production values are used as a baseline measure. However, it has been shown in investigations of L3 learners (e.g. Cruz-Ferreira, 2010), as well as late L2 learners (e.g. Fowler, Sramko, Ostry, Rowland, & Hallé, 2008), that monolingual productions are not comparable to those of speakers with multiple systems that yield bidirectional influence. As Hopp and Schmid (2013) note, “the choice [to use monolingual productions]…serves to move the yardstick of nativelikeness to a point which may, by definition, be out of reach for most bilinguals” (p. 354). In light of findings such as these, it seems clear that a monolingual native norm might not be the most appropriate measurement of L2 ultimate attainment; to this end, Hopp and Schmid (2013) suggest that a more appropriate control group would be a mirror image of the experimental group. That is, if the population under investigation is composed of L1 English speakers that are late L2 learners of Spanish, the control group should consist of L1 Spanish speakers that have acquired L2 English after a certain age and are living in an immersion context. It is important that the controls are late L2 learners rather than simultaneous bilinguals, as Fowler and
colleagues (2008) found that simultaneous French/English bilinguals developed intermediate voiceless stop categories serving both languages, while late bilinguals were shown to have categories that were less assimilatory. Following Hopp and Schmid’s (2013) recommendation, I have tested two groups of controls.

The Spanish control data used to compare with the Spanish experimental data have been collected from speakers (n=10) that have a similar profile to that of the Spanish/English successive bilinguals. That is, these speakers were raised in a monolingual Spanish environment and came to the US after the age of 12. All of the speakers have lived in the US and studied in schools in which the language of instruction is English for a minimum of seven years, and have demonstrated sufficient English proficiency to study in American universities at the graduate level. In order to assure that the body of data obtained was representative of a population of Spanish/English successive bilinguals, speakers could not have fluency in any additional languages.

As with the Spanish control group, BP control participants (n=15) were native speakers of BP that had been raised in a monolingual environment. The onset of acquisition of the speakers’ L2 (either Spanish or English) had to be at or after the age of 12. With the aim of obtaining native BP data from a population with the same languages as the experimental participants, controls were minimally advanced speakers of English, and a subset (n=12) were

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2 Due to technical issues, production data are only reported for nine Spanish control participants.

3 Most US universities require an English proficiency exam as part of their application process. For example, the University of Florida requires a TOEFL (Test of English as a Foreign Language) Internet-Based Test (IBT) score of 80, equivalent to the Common European Framework’s B2 proficiency level (high-intermediate).

4 Due to technical issues, production data are only reported for 14 BP control participants.

5 English proficiency tests were not administered because the intent was to test speakers studying at US universities (see Footnote 4). However, it should be noted that six BP controls were tested in Brazil. Of these six participants,
also advanced speakers of Spanish. To qualify as advanced learners of Spanish, controls had to score a minimum of 80/100 on the same 100-point written proficiency assessment that the L2 Spanish experimental participants completed.

Having presented the experimental and control participants whose perception and production have been examined in this study, the next factor to consider is that of the stimuli and testing paradigms to implement.

4.3 Stimuli Composition and Preparation

A master set of stimuli was formulated for use in all of the experimental tasks, which allowed for direct comparisons across tasks and languages. As per Strange and Shafer, 2008, three principal elements must be considered in stimuli selection: real versus nonce words, context, and synthetic versus natural speech samples. The following paragraphs outline the composition of the stimuli in light of these considerations and the motivations behind such composition.

4.3.1 Stimuli Composition

By using nonce words, Strange and Shafer (2008) argue that participants perform on the basis of phonological and phonetic knowledge rather than lexical knowledge and there is reduced semantic competition. The use of nonce words is also important when testing participants that are either naïve or of low proficiency in comparison with more experienced learners, as is the case in the present study, as it avoids effects that could come from a confound of lexical and phonetic knowledge. Second, by using nonce words, direct comparisons were enabled between the BP and Spanish data without having to rely on cognates. Therefore, to minimize lexical

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6 The use of cognates is avoided in this project given the typological proximity between Spanish and BP and the potential lexical interference that could result. Avoiding cognates (and actual lexical items in general) helps reduce
interference and tap phonological/phonetic knowledge, nonce words were exclusively used in all tasks in both BP and Spanish.

The investigation of individual segments creates a need to address phonetic and phonotactic contexts, since such contexts can alter the acoustic structure of the segment. While use of a single context controls for acoustic modifications and simplifies data analysis, Strange and Shafer (2008) point out that limiting the context precludes findings from being generalizable to other contexts. All critical tokens were disyllabic and phonotactically legal in both languages, and had a /C(C)V.C(C)V/ input structure (e.g. /na.fe/, /pla.ko/). The segment that preceded the critical vowel was equally distributed across voiceless stops /p t k/ and the voiceless fricative /f/. These segments, while allowing for variation in context, were chosen because of their phonetic similarity across Spanish and BP and because their acoustic structure facilitated location of the onset of the following vowel.

All tokens were presented in a carrier phrase in the production and perception tasks that are described in the following section. Not only does the use of a carrier phrase provide a more natural frame for presentation, it also provides the connected speech necessary to motivate vowel reduction.

The carrier phrase used throughout the majority of testing was the same in Spanish and BP:

Spanish:    Es en referencia a ____

BP:         É em referência a ____

‘It is in reference to ____’

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performance differences between native and non-native speakers, as well as between BP learners across different proficiency levels.
The phrase was chosen because it met two criteria: 1) It is similar across the two languages, and 2) it does not contain /e/ or /o/ in unstressed word-final position.

4.3.2 Stimuli Preparation

There is an ongoing debate over whether synthetic speech, modified natural speech, or natural speech is more appropriate as stimuli (see e.g., Strange & Schafer, 2008, for discussion). Synthetic or modified natural speech allows for stimuli to remain constant and to control certain acoustic parameters, and is optimal for testing for effects of modification of portions of the acoustic signal (e.g. deletion of a stop burst or lengthening of vowel duration). Studies have compared responses to the different types of stimuli and have yielded results of similar patterns (e.g. Werker & Lalonde, 1988). However, synthetic speech can often sound artificial, and Strange and Schafer (2008) warn that acoustic parameters that native speakers use to differentiate among categories are not always known and so it becomes difficult to compare data from synthetic and natural speech. Given these considerations, natural speech stimuli were used in the present study. Of course, the use of natural speech is not without its own problems, as the variability from token to token is difficult, if not impossible, to control for. As such, each token had to be analyzed before including it in a task to avoid confounds from variables that could influence performance such as speaking rate and amplitude. Another issue with natural speech is whether to use one speaker or more than one. The use of more than one speaker is more natural, since a naturalistic setting consists of interactions with multiple speakers. However, it has been found that listeners perform better in blocked voice conditions than they do in mixed voice conditions (e.g. Assmann, Nearey, & Hogan, 1982; Mullenix, Pisoni, & Martin, 1989), and that this could be due to an increase in cognitive burden that comes with exposure to more than one speaker (Wong, Nusbaum, & Small, 2004). As such, a single speaker provided all of the stimuli in both Spanish and BP.
Tokens were recorded in Spanish and BP by a bilingual speaker of Spanish and BP. After careful consideration of the evidence surrounding the use of synthetic versus natural speech and one versus multiple speakers for stimuli, all recorded stimuli consisted of natural speech by a single speaker. By doing so, the study is more ecologically valid than the use of synthetic speech, while limiting cognitive load. By using the same speaker, speaker variation across languages is controlled. In addition, given the speaker’s native command of both languages, she was able to produce tokens used for the perception task that had characteristics of both languages. For example, she could produce a token in BP such as /na.fe/, pronouncing a word-final vowel that would normally surface in BP as a reduced vowel ([ˈna.fi]), as a fully-realized vowel ([ˈna.fe]).

The speaker was a 22-year old female that was born in Salvador, Bahia, Brazil. The speaker’s age of onset of acquisition of Spanish was five. With the exception of a two-year return to Brazil between the ages of 13 and 15, she lived and studied in Cuba and Venezuela between the ages of 5 and 18. The speaker is a student of architecture with no linguistic background or formal training in phonetics, phonology, or pronunciation.

Tokens were sampled at a rate of 44.1 Hz, recorded in .wav format on a Marantz PMD661 recorder with a Shure SM10A headmount microphone positioned at a distance of 3 cm from the speaker’s mouth. After a training session with the speaker, three repetitions of each token were recorded within the carrier phrase Es en referencia a__ /É em referência a__, and the clearest repetition was selected for preparation and experimental presentation. Tokens were all produced with penultimate stress and a falling contour.

The tokens were isolated from their carrier phrases in Praat at the nearest zero crossings, and a series of four modifications was made to each token in Praat to prepare each one for presentation. First, all files were normalized such that the intensity was scaled to 70 dB; second,
the first 25 ms and last 25 ms of each token were ramped; third, 5ms of silence were inserted into each end of the token; fourth, the tokens were concatenated with a single sample of the carrier phrase. The carrier phrase had also been ramped and scaled to 70 db, and there were 50ms of silence between the carrier phrase and the token.

Having described the stimuli and their preparation for use in the experiments used in this study, the different paradigms implemented to test production, perception and processing of underlying voiced stops in Spanish and BP are presented.

4.4 Experimental Testing Paradigms

There is a general consensus among L2 phonologists that investigation of the processes of both perception and production is necessary to fully understand the nature of the acquisition of a non-native phonological system (see, e.g., Eckman, Iverson, Fox, Jacewicz, & Lee, 2009, for discussion). Additionally, in the last decade, researchers have begun to utilize online methodologies (that is, methodologies that tap unconscious processing) to observe L2 phonological processing, as these methodologies are arguably sensitive to aspects of L2 acquisition that behavioral methodology cannot access. While it is often difficult to tease apart metalinguistic knowledge and linguistic competence via the use of offline methodologies, online methodologies measure unconscious and automatic response to linguistic stimuli. To address phonological influence as globally as possible, the following battery of tasks, which includes a guided interview, delayed repetition task, and a goodness task, was designed to examine participants’ production, perception, and processing of word-final vowels in Spanish and BP at
different points in the L3 acquisition process. After an overview of the general testing procedures, each task is described in detail.

4.4.1 General Testing Procedure

Testing took place between May and August 2012 in the US and Brazil. Of the 46 experimental participants whose results are reported in Chapters 5 and 6, 23 were tested in Brazil and 23 were tested in the US. Tests in Spanish and BP were administered on different days to control for language mode (see Grosjean, 1998, for a discussion), and the order of languages tested was counterbalanced across participants. Before testing, a language background questionnaire was completed on Survey Gizmo (Appendix A) and participants were recorded for 10 minutes conversing with a native speaker of BP or a near-native speaker of Spanish. The experimental tasks were then administered and task order was counterbalanced across participants, although production always preceded perception testing to limit priming effects. The experimental tasks were completed using E-Prime 2.0 presentation software on an HP G62 465DX Notebook PC. Production data were sampled at a rate of 44.1 Hz, recorded in .wav format using a Marantz PMD661 or Tascam DR-100 mkII recorder and a Shure SM10A head-mount microphone placed at a distance of three cm from the participant’s mouth.

4.4.2 Speech Sample

Each session began with a 10-minute recorded conversation in the language being tested. When testing BP, a native BP speaker (São Paulo dialect) administered the interview. When testing Spanish, the author administered the interview. This speech sample served two purposes:

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7 While an additional production task (a concatenation task adapted from Guion, Clark, Harada, & Wayland, 2003) was completed by all of the participants, only the results from the delayed repetition task are reported in this dissertation.

8 While the plan had originally been to conduct all testing in the US, the equal distribution of participants tested in an immersion vs. non-immersion setting affords the opportunity to analyze immersion context as an independent variable (see Chapter 5 for an overview of the independent and dependent variables).
In addition to providing a speech sample for rating of overall foreign accentedness, the task was fundamental in moving the participants into the relevant language mode. While conversation was spontaneous, topics covered were consistent across participants. To minimize potential rater bias resulting from grammatical errors, topics were chosen requiring grammatical structures of minimal difficulty, such as a description of family members or summer work and study plans. When testing Spanish, the interviewers were careful to avoid the topic of BP in order to limit influence from the other language, and when testing BP, the interviewers avoided the topic of Spanish.

4.4.3 Production

Repetition tasks have been used to control for orthography and literacy. Orthography has been shown to activate a competing grammar (e.g., Shea, 2013), and it is important to control for literacy since many of the heritage speaker bilinguals tested in this study do not have any formal education in Spanish. Repetition tasks can be direct, in which the L2 learner hears a stimulus and repeats it immediately (e.g. Markham, 1997; Snow & Hoefnagel-Höhle, 1977), or after a delay (e.g. Flege et al., 1995). In a delayed repetition task, a target stimulus is presented, followed by distracter speech material, and then the listener is asked to repeat the target stimulus. A delayed repetition task was selected for this study because it is thought to avoid imitation, which is a risk of direct repetition tasks that might result in an inaccurate reflection of L2 production capabilities.

After reading an initial screen with instructions in the language being tested⁹, participants were prompted to complete a 5-trial practice session. All trials were presented auditorily in E-Prime to avoid visual presentation of the stimuli and possible orthographic interference (see Shea, 2013, for evidence of orthographic interference in speech production). As illustrated in

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⁹ See Appendix E for instructions screens for all tasks.
Figure 4-1, each trial began with a 1000 ms fixation screen followed by a 1000 ms blank screen, after which a token was presented auditorily at the end of the carrier phrase *Es en referencia a ___ /É em referência a ___.* Following a 1000 ms interval, the participant heard the distracter question *Es en referencia a qué? /É em referência a que?*, which had been recorded by a native speaker of the language being tested. The question was used to minimize imitation effects, and also served to prompt the participant to produce the target word in the carrier phrase. A blank screen appeared for 3000 ms after the distracter question during which the participant had been instructed to answer the question, followed by a screen with instructions for the participant to press a button when s/he was ready to continue to the next trial.

In addition to five practice trials and 5 warm-up trials that were not considered for data analysis, the main BP block consisted of 105 trials and the SP block consisted of 120. Of these trials, 20 tested vowel reduction, 30 (BP) or 45 (SP) tested post-vocalic voiced stops, and 40 were fillers (see Appendix F for a trial list). Of the 20 critical vowel reduction trials, 10 contained word-final front vowels (/e/, e.g. /fape/), and 10 contained word-final back vowels (/o/, e.g. /kafo/). Fillers were disyllabic nonce words with phonotactically legal word-initial complex onsets (e.g. [ˈpra.mo] SP/[ˈpra.mo] BP, n=10), word-medial complex onsets (e.g. [ˈfas.pɾa] SP/[ˈfas.pɾe] BP, n=10), or a nasal coda (Spanish, e.g. [ˈfiŋ.ɾa]) or nucleus (BP, e.g. [fi.ɾe], n=20). Main block trials were presented in random order by E-prime.

### 4.4.4 Perception and Processing

While there are a number of paradigms that have been used to test native and non-native speech perception, the majority is used to test perception of phonemic contrasts, rather than allophonic contrasts. Given the focus of this study, it was decided that the most effective

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10 Of these 20 tokens, 15 were submitted to acoustic analysis. Tokens consisting of a liquid-vowel final syllable were eliminated from the analysis, due to the challenges in segmentation that stem from the acoustic similarities shared by resonants and vowels.
paradigm would test learner preference for the BP allophone versus the Spanish allophone. Learners therefore completed a goodness task based on one used in a series of studies that investigated the L2 acquisition of stress (Guion, 2005; Guion, Clark, Harada, & Wayland, 2003; Guion, Harada, & Clark, 2004; Wayland, Guion, Landfair, & Li, 2006) in which pairs of sentences were presented auditorily and the listener made a forced-choice judgment indicating which sentence was more native-like. Sentence dyads consisted of a disyllabic nonce word presented auditorily with penultimate or final stress in a carrier phrase.

Reaction time (RT) was recorded to observe potential processing differences (or lack thereof) among the groups. Reaction time, also referred to as mental chronometry, is measured as the amount of time that passes between the presentation of a stimulus and the behavioral response that follows that stimulus. RT is thought to be an index of processing speed, or how fast a person can execute an operation required by a behavioral task. Consequently, processing speed is considered an indication of processing efficiency. Such a measurement was predicted to be especially helpful in the case that behavioral measures (in this case, accuracy in the forced-choice goodness task) did not provide evidence of a statistically significant difference between the groups. While accuracy scores might not reflect a difference, reaction time might, which would then indicate processing differences.

After reading an instruction screen in E-prime written in the language being tested (Appendix F) and completing a 5-item practice block, trials consisted of a fixation screen (1000 ms) and a wait screen (1000 ms) followed by auditory presentation of a pair of experimental (n=50) or filler (n=25) disyllabic words, each presented in the carrier phrase Es en referencia a ___/É em referência a___ (Figure 4-2). Each pair of nonce words was similar, with the exception

11 Only 15 of the experimental trials are reported on in this study, as five were excluded from analysis and the other 30 were used to test the Spanish stop/continuant alternation.
that one word contained an inappropriate allophone and one contained an appropriate allophone.\textsuperscript{12} For example, in the Spanish test, a participant heard a first phrase ending with [ˈna.fe]. After an interstimulus interval (ISI) of 500ms, a second phrase ending with [ˈna.fi] was presented. Given that Spanish word-final vowels do not reduce, the first phrase sounds more natural. While in this example the target phrase is presented second, the order of presentation of target and non-target stimuli was counterbalanced across trials.

The participant was instructed to select the phrase that ended with the word that sounded most natural in the language being tested. The participant had 3000ms to select the word that sounded more natural within the carrier phrase by pressing either ‘1’ or ‘2’ on the computer keyboard. Answers were logged by E-Prime as correct (1) if the participant chose the token with the appropriate allophone within 3000 ms, or incorrect (0) if they chose the token with the inappropriate allophone or did not make a selection within the allotted 3000 ms. Accuracy and reaction time were recorded for analysis.

Having outlined the experimental testing paradigms designed and carried out in this dissertation, the discussion turns to a review of the methodology used to analyze the production data from the delayed repetition task.

\textbf{4.5 Acoustic Analysis}

Given the gradient nature of phonetic vowel reduction such that any intermediate realization between full realization and reduction is possible, it is important to measure the degree of reduction, rather than to treat the phenomenon as binary. The acoustic nature of vowel reduction has been studied extensively over several decades starting with the seminal work by

\textsuperscript{12} The same set of nonce words used in production was used for this perception experiment (see Appendix H for trial list).
Lindblom (1963), and there is ample literature that proposes temporal and spectral measurement criteria for reduced vowels as well as acoustic correlates of intensity.

All measurements were obtained via manual segmentation of the corresponding sound wave in Praat (Boersma & Weenink, 2013). Given the sensitivity of format transitions and trajectories to consonantal coarticulation (Rosner & Pickering, 1994), various criteria employed by Ronquest (2012) and enumerated in the following subsections were used to determine vowel onsets and offsets. Tokens were isolated into separate .wav files and a text grid was created for each file for the purpose of labeling. Once each vowel token had been segmented and labeled accordingly, a Praat script was run on the full set of files that 1) measured the F1 and F2 at the midpoint of each vowel; 2) calculated a) the difference between F2 and F1 values, b) duration (vowel offset-onset), and c) intensity ratio; and 3) appended the set of values into a spreadsheet for statistical analysis.

4.5.1 Vowel Segmentation

Four acoustic cues were used to identify a vowel onset preceded by a voiceless stop consonant ([p t k]) or fricative ([f]): 1) onset of voicing; 2) cyclic repetition (periodicity), 3) onset of clear formant structure; and 4) increase in intensity in both the waveform and spectrogram. Unstressed word-final vowels, especially reduced BP vowels, often evidence formant structures that are not as clear or as stable as their stressed counterparts flanked by consonants. The quality of these word-final vowels make it difficult to rely on criteria that are typically used for vowel offset, one of which is the offset of clear formant structure (e.g., Ronquest, 2012). Duration of voicing has also been used as a criterion for determining the onset and offset of vowels, indicated in the waveform by voicing pulses. However, because many of the productions evidenced creaky voice and thus a break in the voicing pulses, the onset and offset of pulses was not reliable As such, the voicing bar was used as the main criterion for
vowel offset. Figures 4-3 and 4-4 illustrate segmentation of the word-final vowels in Spanish [ˈna.fe] and BP [ˈna.fi].

4.5.2 Metrics

As mentioned, segmented values were measured for F1 and F2 frequencies, F2-F1 difference, vowel duration, and relative intensity. While many researchers consider vowel duration a sole measurement of reduction (e.g. de Jong, McDougall, Hudson, & Nolan, 2007; Hillenbrand, Getty, Clark, & Wheeler, 1995; Lavoie, 2002), others (e.g. Mooshammer & Geng, 2008; White, Payne, & Mattys, 2009) propose that the first and second formant frequency measures in Hertz (F1 and F2) are also a correlate, and work as early as Lindblom (1963) shows a correlation between formant undershoot and decreased vowel duration. F1 is the inverse acoustic correlate of vowel height, whereby low vowels have higher F1 values and high vowels have lower F1 values. F2 is the acoustic correlate of vowel backness, whereby back vowels have lower F2 values and front vowels have higher F2 values. Herrick (2003) measured the average space between the F1 and F2 to determine whether a vowel was reduced, and the same has been done in the present study.

F1 and F2 measurements were taken from the temporal midpoint (50% point) between vowel onset and offset using linear predicting coding (LPC) analysis (Burg algorithm) built into the Praat program via an automated script created by McCloy and McGrath (2012). The midpoint was chosen in order to diminish coarticulation effects from the preceding consonant. Originally, default settings for maximum frequency (5500 Hz for females; 5000Hz for males) and dynamic range (40) were used, and the number of formants analyzed ranged from four to six, depending on gender and whether the vowel was back or front. However, a number of unlikely values were reported due to the F2 being analyzed incorrectly as an F1 for the back vowels, and due to the second tracheal resonance of /e/ being analyzed erroneously as the F2. The unstable
formant structure, particularly with the BP vowels, also led to detection of ghost formants and thus incorrect F1 and/or F2 values. To reduce analysis errors, audio files were resampled to 8000Hz, and the formant ceiling was set to 3000Hz with a maximum of three formants. Any measurements that were judged erroneous using the revised method, were manually corrected based on comparisons of LPC formant tracks and Fast Fourier Transform (FFT) spectra superimposed on the spectrogram.

Once F1 and F2 measurements had been hand-checked, raw formant data were submitted to statistical analysis. While formant value normalization is considered ideal given the variation in formant resonance due to vocal tract size differences (see, e.g., Rosner & Pickering, 1994; Thomas, 2002), raw formant values were used for several reasons. First, the most commonly used normalization methods were not appropriate for use with the data set analyzed in this dissertation. Methods such as Labov’s (Labov, Ash, & Boberg, 2006) are inappropriate because they are speaker extrinsic and calculate a single grand mean for the whole population being tested. Others, such as the Lobanov method (e.g., Adank, Smits, & von Hout, 2004), require measurement of all of the vowels of a language’s inventory. While the Bark Difference Metric (Traunmüller, 1997) does not require measurement of all vowels for all speakers, it does require analysis of F3 frequencies, which were not analyzed as part of this project. The second reason for which normalization was not used is because there were no direct comparisons made between male and female speakers. Third, and most importantly, variation is essentially normalized by including speaker as a random effect in the Mixed Linear Models (MMs) that were used for statistical analysis. As noted by Ronquest (2012), inclusion of speaker as a random effect creates separate intercepts for each speaker, adjusting formant values (as well as each of the other dependent variables analyzed here) statistically. Ronquest’s comparative analysis of both
normalized and non-normalized formants revealed very few differences in the results, supporting her proposal that normalization is not necessary when using an MM and when gender is not an independent variable.

Moving on to relative intensity, recall from Chapter 3 that Parker (2002, 2008) has proposed that intensity (i.e., the perceived loudness of a sound) is the most reliable acoustic correlate of phonological sonority. Parker’s experimental findings echo Ladefoged’s (1975) decades-old proposal that a sound’s sonority is its loudness “relative to that of other sounds with the same length, stress, and pitch” (1975, p. 219). Given Crosswhite’s (2001, 2004) analysis of BP vowel reduction as prominence reduction where prominence is equal to sonority, intensity measurements (in dB) should be relatively lower in reduced vowels.

Considering that intensity is relative and subject to variation, the intensity of a word-final vowel must be compared with the intensity of a neighboring segment. This comparison has traditionally been measured in terms of the difference in the maximum intensity of a vowel and the minimum intensity of a preceding consonant (IntDiff, e.g. Hualde, Simonet, Shosted, & Nadeu, 2010), the ratio between the minimum intensity of a consonant and the maximum intensity of a tautosyllabic vowel (IntRatio, e.g. Romero, Parrell, & Riera, 2007), and the maximum rising velocity of an intensity curve between a consonant’s minimum intensity and a vowel’s maximum intensity (MaxVel, e.g. Kingston, 2008). Of the three methods, Parrell’s (2010) found that IntRatio is the most accurate measurement. However, because intensity was measured in decibels (dB) and dB is a logarithmic unit (i.e., a ratio scale), dB cannot be divided. Therefore, IntDiff was measured in the present study since it was found to be the second most reliable calculation. Because the consonant coarticulated with the word-final vowel was not controlled for, IntDiff was measured as the maximum intensity of the word-final vowel.
subtracted from the maximum intensity of the penultimate vowel (always /a/ of each disyllabic token. The lower the relative intensity of the word-final vowel, the more reduced the vowel is assumed to be. Word-final segments that are more fully realized will have a higher maximum intensity and therefore will yield lower IntDiff values than the word-final syllables with less fully realized vowel segments. An automated calculation of IntDiff was made via a Praat script written by Arantes (2004) and revised by Sarmah (2012) that 1) measured the maximum intensity of each stressed vowel and the maximum intensity of the following unstressed vowel; 2) calculated the intensity difference; and 3) appended the set of IntDiff values into a spreadsheet for statistical analysis. The results of the statistical analysis of the production data will be reported in Chapter 6.

4.6 Summary

This chapter has outlined the methods implemented for participant selection, categorization, and testing, stimuli design, and data analysis. By measuring the perception, processing, and production of word-final unstressed vowels in Spanish and BP via implementation of the methodology presented, it has been possible to investigate not only the acquisition of L3 BP by different profiles of Spanish/English bilinguals, but also to observe at what point and to what extent, if any, there are modifications of the native and non-native Spanish speakers’ phonological system as it relates to vowel reduction. The goal has been to control for as many variables as possible while recognizing that logistics and practicality must also be regarded when testing this hypothesis of L3 regressive transfer. In the following chapter, the perception data are presented and discussed, and in Chapter 6, the results of the acoustic analysis of the production data are presented.
Table 4-1. Experimental and control groups.

<table>
<thead>
<tr>
<th>L3 BP proficiency</th>
<th>Group</th>
<th>n =</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediate</td>
<td>1. L1 English/L2 Spanish</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>2. L1 Spanish/L2 English</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>3. Heritage speaker Spanish/English</td>
<td>14</td>
</tr>
<tr>
<td>Advanced</td>
<td>4. L1 English/L2 Spanish</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>5. L1 Spanish/L2 English</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>6. Heritage speaker Spanish/English</td>
<td>5</td>
</tr>
<tr>
<td>Controls</td>
<td>7. L1 Spanish/L2 English</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>8. L1 BP/L2 and L3 English/Spanish</td>
<td>15</td>
</tr>
</tbody>
</table>

Table 4-2. Advanced Spanish proficiency criteria.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Criterion scale/value</th>
<th>Minimum requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proficiency test</td>
<td>0-100</td>
<td>80</td>
</tr>
<tr>
<td>Accent rating</td>
<td>1-7</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 4-3. BP proficiency criteria.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Criterion scale/value</th>
<th>Intermediate</th>
<th>Advanced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proficiency test</td>
<td>0-100</td>
<td>50-80</td>
<td>81-100</td>
</tr>
<tr>
<td>Accent rating</td>
<td>1-7</td>
<td>1-3</td>
<td>4-7</td>
</tr>
</tbody>
</table>
Figure 4-1. Stimulus presentation for delayed repetition task (Spanish version).

Figure 4-2. Stimulus presentation for perception task (Spanish version).
Figure 4-3. Segmentation of Spanish [ˈna.fe].
Figure 4-4. Segmentation of BP [ˈna.ʃi].
CHAPTER 5
PERCEPTION RESULTS

5.1 Overview

This chapter details the results of the experimental perception task. As reviewed in Chapter 4, the task was administered to experimental and control participants in a timed environment, and participant responses were recorded for accuracy and reaction time (RT). Beyond a descriptive examination of the data, Mixed Linear Models (MMs) with Bonferroni post-hoc tests allowed for intragroup comparisons. Although potential differences between the experimental groups’ whose Spanish was acquired in childhood versus adulthood is the focus of this study, the results of the learners’ performance on the BP task are also presented, since BP development is predicted to motivate attrition. In addition, longitudinal data from the L1 English/L2 Spanish/L3 advanced BP case study introduced in Chapter 4 are presented.

To analyze the case study data, control data were used to construct a 95% confidence interval for accuracy and RT in Spanish and BP; these intervals served as a range of plausible (average) accuracy and RT for the experimental task. Once confidence intervals were established, Draco’s results were compared quantitatively and qualitatively with those of the control samples. A paired-samples t-test was also used to compare Draco’s Spanish accuracy data from his pre-BP and post-BP testing sessions. Lastly, the cross-sectional and case study analyses were considered with respect to the predictions of the PPH and the possible outcomes outlined in Chapter 2.

5.2 Goodness Task

Recall that the goodness task tested for preference of phonetically reduced or fully realized vowels in word-final position in disyllabic CV.CV nonce words with penultimate stress. As discussed in Chapter 3, BP has a phonetically reduced vocalic inventory of [ə i ʊ] in word-
final position, while Spanish has a fully realized vocalic inventory of [a e i o u] regardless of position or stress. The task was limited to word-final vowel inputs of /e/ (n=10) and /o/ (n=10), which surface in Spanish as [e] and [o] and in BP as reduced [ɪ] and [ʊ], respectively. It was therefore predicted that when presented with a choice between reduced and unreduced word-final vowels, the Spanish controls would prefer unreduced vowels while BP controls would prefer reduced vowels. Accuracy results from BP and Spanish are presented first, followed by RT data.

5.2.1 Accuracy

5.2.1.1 BP

A summary of group accuracy means by vowel type (front /e/ or back /o/) in BP is presented in Figure 5-1, and overall group means in Figure 5-2. Error bars indicate the 95% confidence interval for each group. An MM with Bonferroni post hocs was run on the BP accuracy data with Accuracy as the dependent variable, and with independent variables of Group (7 levels) and Vowel (two levels). A second set of analyses was run without the control data with the within-subjects variable Immersion (two levels). These analyses compared the accuracy of the different experimental groups according to whether learners had been tested in an immersion environment, and followed from research on L2/L3 immersion effects on the L1, which indicates an increase in L3 activation in an immersion setting (Poarch & van Hell, 2013) and that L2 immersion can impact processing in the L1 (Dussias & Sagarra, 2007). Thus, the analyses run with Immersion as an independent variable were implemented to determine whether context and amount of use at the time of testing might have an effect on accuracy, and particularly on RT. Type III Tests of Fixed Effects evidenced no significant interaction (Group*Vowel: F (6, 1071.48) = .439; p = .853) or main effects (Group: F (6, 54.13) = 1.100; p = .374; Vowel: F (1, 1071.25) = .2859; p = .091). The analysis of Immersion as an independent variable returned an insignificant p-value for Immersion*Group*Vowel (F (5, 802.66) = 1.431; p = .211).
Immersion*Group (F (4, 35.24) = 1.943; p = .125), and Immersion (F (1, 44.24) = 1.039; p = .314). The lack of significant effects of Vowel on Accuracy indicates that accuracy was not affected by whether the vowel tested was front (/e/) or back (/o/) or by the amount and context of use. More importantly, the lack of significant effect of Group on Accuracy suggests that there were no significant differences in accuracy between groups. That is, BP learners preferred phonetically reduced unstressed word-final vowels at the same rate as the BP controls, regardless of stage of BP development or age of acquisition of Spanish.

It is interesting to note that none of the groups perform at ceiling, including the BP control group. Fully realized unstressed word-final vowels are attested in exaggerated speech in BP, and anecdotal evidence suggests that native speakers might interpret fully realized vowels as ‘correct’ or ‘educated’ speech. This association could stem from an (inaccurate) metalinguistic phone-grapheme correspondence, since the associated word-final graphemes in orthographically shallow BP are ‘e’ and ‘o’. While plausible that learners’ scores are similar to those of the controls for the same reason and have indeed acquired BP stress-conditioned vowel reduction, it is also conceivable that learner means indicate that they are still in the process of acquiring stress-conditioned word-final vowel reduction. It is therefore important to tread with caution when making any generalizations regarding learner acquisition based on the data from this perception task.

Whether learner outcomes are in fact native-like or acquisition is still ongoing, it is of interest that intermediate BP learner data is similar to advanced BP learner data. Many of the intermediate participants had had only 16 weeks of classroom instruction and had never been in

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an immersion context, suggesting the possibility that word-final vowel reduction is very salient and robust in the input, in turn driving rapid rereanking of constraints in L3 BP.

**Case study data.** As evident in Table 5-1 and the right-most bar(s) in Figures 5-1 and 5-2, Draco’s accuracy data shows that he is testing nearly at ceiling after 11 weeks of intensive exposure to BP, preferring reduced word-final unstressed vowels 19 out of 20 times. Comparing his overall mean with the 95% confidence interval for the BP control group (66.8%-86.0%) created by the MM and shown via the error bar in Figure 5-2, his score falls above the interval. It also falls above the interval of his peer L1 English advanced BP group, and is separated from the overall mean accuracy for the advanced BP groups (77%) by more than one standard deviation (17%). Comparing means by vowel type, Draco’s means again fall above the confidence interval for both front /e/ (65.7%-87.0%) and back /o/ (65.7%-87.1%). Given his near-ceiling performance and the difference between his accuracy score and the average learner accuracy scores, his data tentatively support the proposal that learner means could reflect acquisition still in progress, rather than acceptance of fully realized vowels as exaggerated BP speech.

**Revisiting predictions.** In the discussion of the L3 learning task (Section 3.3.2), it is predicted that L1 Spanish learners will be slower than L2 Spanish learners to acquire BP vowel reduction (i.e., to demote relevant feature faithfulness constraints and promote relevant prominence reduction constraints) given the relatively entrenched nature of their early-acquired system. Similarly, it is predicted that L2 Spanish learners will be comparably faster than L1 Spanish learners to demote/promote relevant constraints in BP 1) because their Spanish system is not as entrenched and 2) due to possible facilitation from their L1 English system, which exhibits a similar pattern of vowel reduction. Considering the lack of significant difference between L1
and L2 Spanish group means independent of BP proficiency level, this prediction is not supported for the accuracy data.

5.2.1.2 Spanish

A summary of group accuracy means by vowel type (front/back) in BP is presented in Figure 5-3, and overall group means are presented in Figure 5-4. Error bars indicate the 95% confidence interval for each group. An MM with Bonferroni post hocs was run on the Spanish perception data with the same variables of Group (7 levels) and Vowel (two levels), with a separate analysis run on the experimental groups’ data that incorporated Immersion as a variable (two levels). The dependent variable was again Accuracy. Type III Tests of Fixed Effects did not return a significant Group*Vowel interaction (F (6, 1076) = 1.025; p = .407), but a reduction of the model showed Group to be a significant main effect (F (6, 50) = 2.581; p = .03). However, post-hoc analysis revealed that the significant difference in accuracy between groups was due to the fact that the L1 English intermediate group had a significantly higher rate of accuracy (p = .027). Immersion was not found to have any type of effect (Immersion*Group*Vowel: F (5, 1071) = .411; p = .841; Immersion*Group: F (4, 45) = .649; p = .631; Immersion (1, 45) = .057; p = .812). Thus, as found in the BP data, the lack of significant effects of Vowel and Immersion on Accuracy indicate that accuracy was not affected by whether the vowel tested was front (/e/) or back (/o/) or by context and amount of use of BP. More importantly, the lack of significant effect of Group on Accuracy suggests that there were no significant differences in accuracy between groups. That is, regardless of the status of the participant’s Spanish system as early- or late-acquired and regardless of where the learners were in their L3 BP development, all of the experimental learners performed in line with the Spanish control group.

As in BP, none of the groups perform at ceiling, including the Spanish control group. It is possible that the controls and near-native speakers accept the word-final reduced vowels [ɪ ʊ] as
natural in Spanish 25% of the time because of the reduced segments’ proximity in the vowel space (i.e., similar F1 and F2 values) to fully realized [i u]. The fact that the controls and learners do not prefer [i u] more than 25% of the time could be due to the fact that 1) they are phonetically reduced and 2) that [i u] in word-final position in Spanish are infrequent in comparison to word-final [a e o], tending to be limited to words of indigenous origin (e.g. miski [ˈmis.ki], from Quechua ‘sweet’) or as a colloquial diminutive (e.g. guapi [ˈɡua.pi] ‘good-looking, chati [ˈtʃa.ti] ‘darling’) (de Prada Pérez, personal communication, January 27, 2013).

Case study data. Given that Draco’s Spanish was tested prior to BP exposure and again 11 weeks after initial exposure, it is possible to 1) compare his two data sets via a paired-samples t-test and 2) compare his post-BP exposure data set with with the cross-sectional data. As illustrated in Table 5-2, Draco tested at 90% overall accuracy (9/10, 90% front /e/ and 9/10, 90% back /o/) in his first testing session and 80% in his second testing session 11 weeks later. The 80% overall accuracy score stemmed from 100% accuracy on the items containing front /e/ and only 60% accuracy on items containing back /o/). A paired-samples two-tailed t-test confirmed that the 10% negative change in accuracy over the course of 11 weeks was not significant (p = 1.000). Separate t-tests also confirmed that there were no significant differences when the front (p = .331) and back (p = .135) accuracy scores from each session were compared separately.

Comparing Draco’s 80% accuracy score with the 95% confidence interval for the SP control group created by the MM and shown via the error bar in Figure 5-4 (68.3%-81.7%), his score falls within the interval, and just barely within the confidence interval of his peer L1 English advanced BP group (79.3%-94.1%). While there was no interaction between group and

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3 It is of course also conceivable in the case of the experimental participants that BP influence is at play, but that would not explain the control accuracy scores, and longitudinal data would be necessary to confirm such a conjecture.

4 See e.g., Cotton (1988), for reports of indigenismos in contemporary Spanish in the Americas.
vowel type, for the sake of descriptive thoroughness it is noted that Draco’s front /e/ accuracy mean falls above the control confidence interval (63.1%-80.5%) while his back /o/ mean falls below the control interval (69.5%-86.9%). These data thus largely support the L2 Spanish data, that is, there is no evidence to support differential accuracy in Spanish determined by age of acquisition.

5.2.1.3 Interim summary: Accuracy

The tenets of the PPH predict that the phonological system of an early acquirer of Spanish will be less vulnerable to influence from BP phonology over time than the system of a late acquirer of Spanish. Given that there are no statistically significant differences among the control and six experimental groups in the perception experiment, the cross-sectional data indicate that in terms of a preference for fully realized mid vowels [e o] versus phonetically reduced [ɪ ʊ] in word-final unstressed syllables, Spanish speakers maintain a native-like preference for mid vowels regardless of the status of the Spanish system as early or late acquired, of the stage in BP development (intermediate vs. advanced), and of whether they were in an immersion context at the time of testing. Draco’s data support the L2 Spanish data, as his post-BP accuracy score falls within the 95% confidence interval of the Spanish control data. Additionally, a comparison of his pre-and post-BP Spanish perception accuracy does not evidence a statistically significant change, indicating that even after acquiring advanced proficiency in L3 BP, there is no change in terms of his preference for fully realized over phonetically reduced vowels in word-final unstressed position, independent of vowel type.

As outlined in Chapter 2, there are three possible outcomes with respect to the PPH, which are repeated below for reference.

1. Possible outcome 1. There are no statistically significant differences between groups in either the perception or production data. This outcome does not support the PPH.
2. Possible outcome 2. Both the perception and production data yield statistically significant differences between the groups of early and late acquirers, indicative of a higher degree of instability of the Spanish mental representation among the late acquirers. Such an outcome would support the PPH.

3. Possible outcome 3. There are no statistically significant differences in the L1 and L2 Spanish perception data, but there are differences across the groups’ production data. Production differences might be the result of processing issues in terms of inhibitory control. While such data does not support the PPH in its strong form, data supports differences in terms of stability, albeit at the level of processing.⁵

Taken on their own, the accuracy data and lack of a Group effect thus far would seem to question the possible outcome of a difference between L1 and L2 groups at the levels of perception and production (Possible outcome 2), while initially supporting the other two potential outcomes. The comparable stability of the early and late acquirers in terms of word-final unstressed vowel preference potentially indicates a stable mental representation in terms of constraint ranking fluctuation, and as the discussion moves on to RT data for the perception task, it might become clearer which of the two remaining outcomes will be further supported. If RT data yield a difference between early and late acquirers, it could be possible to claim that differences are due to processing.

5.2.2 Reaction Times

Mean RTs are presented in milliseconds and represent accurate responses only.⁶ As is standard, to reduce contamination of the means due to inattention (prolonged RTs), the data set was trimmed such that RTs that were more than two standard deviations (SDs) away from the overall mean RT were excluded from analysis.

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⁵ It is assumed here that there is one grammar composed of a set of universal constraints, and that constraint rankings are accessed during processing and shape both perception and production. For alternative accounts of separate perception and production grammars in OT, see e.g., Boersma (1999).

⁶ RTs from inaccurate responses are typically excluded from analysis under the assumption of an additional component process operating on an inaccurate trial (see e.g., Hopp, 2007).
5.2.2.1 BP

A summary of group RT means by vowel type (front/back) in BP is presented in Figure 5-5, and overall group means are presented in Figure 5-6. Error bars again indicate the 95% confidence interval for each group. Of the total 1220 data points, there were 82 missing responses (6.7%) and 288 incorrect responses, or 23.6% of the total. Of the remaining 850 correct responses (mean = 720.9 ms, SD = 499.09), there were 48 outliers that were more than 2 SDs above the mean (>1719 ms), or 05.6% of the correct responses. The final data set submitted to statistical analysis consisted of 802 data points.

A Mixed Linear Model (MM) with Bonferroni post hocs was run on the BP RT data with the independent variables of Group (7 levels) and Vowel (two levels). A second set of analyses was run on the experimental data with the within-subjects variable Immersion (two levels). The dependent variable for both sets of analyses was RT (ms). Type III Tests of Fixed Effects evidenced a Group*Vowel interaction approaching significance (F (6, 750.63) = 2.086; p = .053). Upon further inspection of Group and Vowel, there were no significant RT differences between groups conditioned by front vs. back vowels. However, the L1 Spanish intermediate BP group evidenced shorter RTs for back vowels (p = .003). After reducing the model, Group was not significant (F (6, 53.52) = 1.162; p = .340). Immersion context was not found to be a predictor of RT difference between groups (Immersion*Group*Vowel: F (5, 549.40) = .349; p = .883; Immersion*Group: F (4, 38.22) = .896; p = .476; Immersion (1, 41.32) = .022; p = .883).

The lack of significant RT differences between groups (with the exception of the the L1 Spanish intermediate groups’ faster back vowel RTs) suggest homogenous processing speeds for accurate selection of phonetically reduced unstressed word-final vowels in BP. As was found with the accuracy data, despite the status of the participant’s Spanish system as early- or late-acquired and regardless of where the learners were in their L3 BP development and where they
were tested, all of the experimental learners performed in line with the BP control group in terms of accurate decision-making speed in BP.

**Case study data.** Draco’s BP data are summarized in Table 5-3 and illustrated in the right-most bar(s) in Figures 5-5 and 5-6. Comparing his overall mean BP RTs with the 95% confidence interval for the BP controls (522-766 ms), his score falls above the upper limit, indicating longer processing times for accurate selection of phonetically reduced unstressed word-final vowels. Compared with his peer L1 English advanced BP group, his overall mean RT also falls above the upper limit of the 95% confidence interval (519-834 ms). Thus, while his accuracy mean fell above the confidence interval of the BP control and his peer group, he evidences longer RTs than both groups.

Observing differences across vowel type, Draco’s front /e/ and back /o/ RTs each come in well above the BP control group confidence interval (518-776 ms and 512-772 ms, respectively). Compared with his peer group’s data, his RTs fall within the confidence interval for back /o/ (435-939 ms) but above the interval for front /e/ RTs (410-907 ms). Given the disparity between Draco’s BP longer RTs and those of the controls and his peer group, it is possible that his increased accuracy comes at a processing cost, suggesting a larger search space resulting in additional time needed to access the BP grammar. However, this is only speculation that cannot be confirmed without additional data.

**Revisiting predictions.** Returning to the prediction addressed in Section 5.2.1.1 with respect to the accuracy data, it is noteworthy that the BP RT data lines up with the prediction that L2 Spanish learners will acquire BP vowel reduction faster than L1 Spanish learners. Had the L1 Spanish RTs been significantly slower than the L2 Spanish RTs even though the accuracy data were not significantly different, it is possible that although the temporal nature of the acquisition
process seems to be similar, acquisition comes at a higher processing cost to the L1 Spanish speakers. However, given the lack of significant differences between L1 and L2 Spanish group RT means across BP proficiency levels, this prediction is not supported.

5.2.2.2 Spanish

Of the total 1140 data points, there were 180 incorrect responses, or 15.8% of the total. Of the remaining 960 correct responses (mean = 699.2 ms, SD = 508.5), there were 52 outliers that were more than 2 SDs above the mean (>1716.2 ms), or 05.4% of the correct responses. The final data set submitted to statistical analysis consisted of 908 data points.

The Type III Tests of Fixed Effects from the MM evidenced a significant Group*Vowel higher-order interaction (F (6, 847.40) = 2.542; p = .019). As was the case in Spanish, pairwise comparisons showed a lack of significant RT differences between groups conditioned by front vs. back vowels, although vowel type was a significant predictor of RT for the Spanish control group and L1 English advanced BP group. The Spanish control group had shorter RTs for back vowels (p = .014), while the L1 English advanced BP group had shorter RTs for front vowels (p = .024). Reducing the model, Group was not significant (6, 48.98) = .951; p = .468). As found with the BP data, immersion context was not found to be a predictor of RT difference between groups (Immersion*Group*Vowel: F (5, 840.12) = .405; p = .846; Immersion*Group: F (4, 43.78) = 1.405; p = .248; Immersion (1, 43.85) = 2.051; p = .159).

The lack of significant RT differences between groups suggest homogenous processing speeds for accurate selection of fully realized unstressed word-final vowels in Spanish. As was found with the accuracy data, regardless of the status of the participant’s Spanish system as early- or late-acquired, of where the learners were in their L3 BP development, and of whether they were in an immersion context at the time of testing, all of the experimental learners performed in line with the Spanish control group in terms of accurate decision-making speed.
**Case study data.** As with the accuracy data, Draco’s Spanish RT data collected prior to exposure were first compared with his RT data taken 11 weeks after initial BP exposure. The number of correct responses for each condition was not equal, and therefore it was not possible to conduct a one-to-one comparison of pre-and post-BP Spanish RTs via a paired-samples t-test. Therefore, while descriptively speaking it would seem that Draco’s overall RTs have become shorter while his back /o/ RTs are slower across sessions than his front /e/ RTs, it is not possible to know whether the difference evidenced is statistically significant.

Draco’s post-BP Spanish data set was also compared with the cross-sectional data. Comparing his mean RTs with the 95% confidence interval for the Spanish controls (689-859 ms), his score falls above the upper limit. Compared with his peer L1 English advanced BP group, his overall mean RT also falls above the upper limit of the 95% confidence interval (564-802 ms). However, given the lack of statistical analysis of his pre- and post-test data, it is not possible to suggest that this difference is indicative of a change in processing time due to BP influence.

Observing differences across vowel type, Draco’s front /e/ RTs fall within the SP control group confidence interval (619-802 ms), although his pre-test front /e/ RTs fell above the upper limit of the interval. His back /o/ RTs come in well above the control confidence interval (493-931 ms) in both testing sessions. Comparing Draco’s post-test data with his peer group’s data, he patterns with the L1 English advanced BP group in that front /e/ mean RTs were significantly faster than their back /o/ mean RTs. However, comparing Draco’s RTs with those of the L1 English advanced BP group, he falls within the confidence interval for front /e/ RTs (446-949 ms) but above the interval for back /o/ RTs (575-999 ms).
While statistical analysis does not point to BP influence on processing in Spanish, a review of the slower /o/ RTs combined with the decrease in /o/ accuracy (albeit an insignificant decrease) and the RTs that fall outside of the CIs leads to the conclusion that the possibility of increased processing costs in Spanish perception should not be ruled out and should be explored further with more longitudinal data. Having reported the accuracy and RT data from the cross-sectional study and case study, the results will now be addressed together with respect to the predictions of the PPH and the possible outcomes initially addressed in the interim summary.

5.3 Discussion and Summary

In Section 5.2.1.3, the lack of significant effects in the accuracy data led to the conclusion that two of the three possible outcomes posited in Chapter 2 were thus far supported. However, without RT and production data, it was not possible to narrow down the possible outcomes any further. The suggestion was made that RT data might support one of the two outcomes depending on the shape the data took. A lack of statistically significant differences in RT data across L1 and L2 Spanish speakers and the Spanish control groups would suggest equal invulnerability to L3 BP influence at the level of mental representation and processing in speech perception, offering further support for Possible Outcome 1, and therefore not supporting the PPH. On the other hand, RT differences between L1 and L2 Spanish speakers would support Possible Outcome 3 and, as a result, a weaker version of the PPH in which differential stability occurs at the level of processing rather than mental representation. In such a case, rather than attrition, which is defined in the present study as modification of the mental representation, executive control functions would be responsible for BP influence.

At first glance, it would seem that the RT data give footing to Possible Outcome 1, i.e., equal resistance to BP influence by early and late acquirers of Spanish. There is a dearth of statistical significance in the differences among the mean RTs of all of the experimental groups
and the Spanish control group, independent of when and where Spanish was acquired, the stage of L3 BP development, and context in which testing occurred. Although Draco’s mean RTs fall above the 95% confidence interval of the controls and the L1 English advanced BP group, suggesting that his 95% accuracy comes at a processing cost, statistical analysis comparing his pre- and post-BP data was not possible and therefore conclusions cannot be made based on his data alone. Thus, without statistically significant support from the case study data, it is only possible to posit that Spanish RTs remain stable throughout the course of L3 BP acquisition for native and non-native speakers alike. Executive control functions are necessary for focusing attention on Spanish and to filter interference from BP, and crucially to select among competing constraint rankings as stated by the Constraint Fluctuation Hypothesis (Goodin-Mayeda et al., 2011).\(^7\) The results presented here do not support a difference in inhibitory control during perception conditioned by age of acquisition of Spanish or L3 proficiency, although additional data will be needed to bolster these findings.

The production data presented in Chapter 6 will shed more light on whether the stability evidenced for perception and processing during perception extends to production. Should there be significant differences between the L1 Spanish and L2 Spanish speakers, an asymmetry in perception and production will indicate processing differences in Spanish production and support a weak version of the PPH, or Possible Outcome 3. However, in the case of evidence of comparable (in)stability between the L1 Spanish and L2 Spanish learners, Possible Outcome 1 will be supported, providing evidence that does not support the PPH.

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\(^7\) See e.g., Ye and Zhou (2009) for a discussion of executive control and perception.
Table 5-1. Case study BP accuracy data (%).

<table>
<thead>
<tr>
<th>BP testing session</th>
<th>Front /e/ mean Acc</th>
<th>Back /o/ mean Acc</th>
<th>Overall mean Acc</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>90% (9/10)</td>
<td>100% (10/10)</td>
<td>95% (19/20)</td>
</tr>
</tbody>
</table>

Table 5-2. Case study Spanish Accuracy data (%).

<table>
<thead>
<tr>
<th></th>
<th>Front /e/ mean Acc</th>
<th>Back /o/ mean Acc</th>
<th>Overall mean Acc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-BP Spanish</td>
<td>90% (9/10)</td>
<td>90% (9/10)</td>
<td>90% (18/20)</td>
</tr>
<tr>
<td>Post-BP Spanish</td>
<td>100% (10/10)</td>
<td>60% (6/10)</td>
<td>80% (16/20)</td>
</tr>
</tbody>
</table>

Table 5-3. Case study BP RT data (ms).

<table>
<thead>
<tr>
<th>BP testing session</th>
<th>Front /e/ mean RT</th>
<th>Back /o/ mean RT</th>
<th>Overall mean RT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1049 (n = 7)</td>
<td>847 (n = 9)</td>
<td>936 (n = 16)</td>
</tr>
</tbody>
</table>

Table 5-4. Case study Spanish RT data (ms).

<table>
<thead>
<tr>
<th></th>
<th>Front /e/ mean RT</th>
<th>Back /o/ mean RT</th>
<th>Overall mean RT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-BP Spanish</td>
<td>834 (n = 8)</td>
<td>1145 (n = 7)</td>
<td>979 (n = 15)</td>
</tr>
<tr>
<td>Post-BP Spanish</td>
<td>668 (n = 10)</td>
<td>1327 (n = 5)</td>
<td>888 (n = 15)</td>
</tr>
</tbody>
</table>
Figure 5-1. Group means of percent accuracy in BP perception task by vowel type, where solid bars denote front /e/ and shaded bars denote back /o/.

<table>
<thead>
<tr>
<th>Group</th>
<th>Front /e/</th>
<th>Back /o/</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP cont</td>
<td>76.3%</td>
<td>76.4%</td>
</tr>
<tr>
<td>L1 SP int</td>
<td>73.7%</td>
<td>71.3%</td>
</tr>
<tr>
<td>L1 SP adv</td>
<td>83.3%</td>
<td>75.9%</td>
</tr>
<tr>
<td>HS int</td>
<td>68.4%</td>
<td>62.7%</td>
</tr>
<tr>
<td>HS adv</td>
<td>81.5%</td>
<td>70.4%</td>
</tr>
<tr>
<td>L1 EN int</td>
<td>88.0%</td>
<td>81.1%</td>
</tr>
<tr>
<td>L1 EN adv</td>
<td>76.3%</td>
<td>78.0%</td>
</tr>
<tr>
<td>L1 EN cs</td>
<td>88.9%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

A) BP cont = BP control group. B) L1 SP int = L1 Spanish/L2 English intermediate L3 BP group. C) L1 SP adv = L1 Spanish/L2 English advanced L3 BP group. D) HS int = Heritage Speaker intermediate L3 BP group. E) HS adv = Heritage Speaker advanced L3 BP group. F) L1 EN int = L1 English/L2 Spanish intermediate L3 BP group. G) L1 EN adv = L1 English/L2 Spanish advanced L3 BP group. H) L1 EN cs = L1 English/L2 Spanish case study (advanced L3 BP).
Figure 5-2. Group means of percent accuracy in BP perception task.

Figure 5-3. Group means of percent accuracy in Spanish perception task by vowel type, where solid bars denote front /e/ and shaded bars denote back /o/.
Figure 5-4. Group means of percent accuracy in Spanish perception task.

Figure 5-5. Group means of RT (ms) by vowel type in BP perception task.
Figure 5-6. Overall group means of RT (ms) in BP perception task.

Figure 5-7. Group means of RT (ms) by vowel type in Spanish perception task.
Figure 5-8. Group means of RT (ms) in Spanish perception task.
CHAPTER 6
PRODUCTION RESULTS

6.1 Overview

This chapter details the results of the delayed repetition production task. As reviewed in Chapter 4, the task was administered to experimental and control participants, and recorded participant responses were analyzed acoustically. Beyond a descriptive examination of the data, Mixed Linear Models (MMs) with Bonferroni post-hoc tests allowed for intragroup comparisons. Although the experimental groups’ Spanish is the focus of this study, the results of the learners’ performance on the BP task are also presented, since BP development is predicted to motivate attrition. In addition, longitudinal data from the L1 English/L2 Spanish/L3 advanced BP case study are presented to substantiate (or not) the results of the cross-sectional study.

As was done with the perception data, to analyze the case study data, control data were used to construct a 95% confidence interval for each of the metrics in Spanish and BP. These intervals served as a range of plausible measures for the experimental task. Once confidence intervals were established, Draco’s (the focus of the case study) results were compared quantitatively and qualitatively with those of the control samples. Paired-samples t-tests were also used to compare Draco’s Spanish data from his pre-BP and post-BP testing sessions. Lastly, the cross-sectional and case study analyses were considered with respect to the predictions of the PPH and the perception results reviewed in Chapter 5.

6.2 Delayed Repetition Task Results

The delayed repetition task was implemented to examine word-final vowel production in disyllabic CV.CV nonce words with penultimate stress. The task was limited to word-final vowel
inputs of /e/ (n=7) and /o/ (n=8)\(^1\), which typically surface in Spanish as [e] and [o] and in BP as reduced [i] and [o], respectively. Productions were analyzed in Praat for F1, F2, and F2-F1 difference (Hz), duration (ms), and relative intensity (dB) to determine the control and experimental participants’ vowel quality in each language. Comparisons were made between the Spanish and BP control data to establish vowel quality differences in the two languages, and a second set of analyses compared the six experimental groups and control group for each language. Each of the five metrics was analyzed as a continuous dependent variable in an MM, with categorical between-subjects variable ‘Group’ and within-subjects variable ‘Vowel’ as fixed effects, and ‘Participant’ as a random effect. For the analysis comparing the Spanish and BP control data, the between-subjects variable was ‘Language’. A third set of analyses was run exclusively on the experimental data, this time incorporating the categorical between-subjects variable ‘Immersion’ as a fixed effect. Estimated marginal means (EMMs) (as opposed to raw averages) and standard error (SE) as determined by the MMs are presented throughout, with the exception of the raw means from the case study data.\(^2\) The next sections detail an acoustic comparison of BP and Spanish control data to establish baselines for comparison with experimental data. Once relevant cross-linguistic acoustic differences are established, group and case study results are presented for BP first, followed by Spanish.

6.2.1 BP Control Vowel Quality

As discussed in Chapter 3, underlying /e/ and /o/ surface in BP as [i] and [o], respectively (e.g., Cristófaro-Silva, 2002, p. 86). As seen in the vowel chart in Figure 6-1 that follows from Barbosa and Albano (2004) and illustrates the word-final surface vowel inventory, [i] is a near-

\(^1\) The task included 10 front /e/ tokens and 10 back /o/ tokens; however, the five tokens containing word-final vowels preceded by a liquid were excluded from analysis due to the unclear vowel onset that impeded accurate duration measurements.

\(^2\) Recall that formant values were not normalized since Participant was a random effect in the MM (see Chapter 4 for discussion).
high, near-front, unrounded vowel, and [ʊ] is a near-high, near-back, rounded vowel. Recall the discussion in Chapter 3 that the scale of sonority for vowels is determined first by height, and then by peripheral quality. BP word-final vowels are lower in sonority than BP [e] and [o], as they are less peripheral and are also higher.

From the 210 tokens recorded from the sample (n=14), 192 were submitted to analysis. Three were excluded from analysis due to complete devoicing, and another 15 were excluded because of mispronunciation. A total of 24 tokens had unstable formant structure and only duration and relative intensity (IntDiff) values were analyzed. Table 6-1 outlines the average first formant (F1) frequency, second formant (F2) frequency, F2-F1 difference, duration (measured in milliseconds, ms), and relative intensity (IntDiff, measured in decibels, dB). As a visual representation of the F1 and F2-F1 values, Figure 6-1 illustrates that the BP control productions are in line with the height and backness of [i] and [ʊ] as per Barbosa and Albano (2004).

The front and back vowels differ from one another significantly in terms of height (F1) and backness (F2). Back vowels have a significantly higher mean F1 (p < .001), front vowels have a significantly higher F2 (p < .001), and F2-F1 difference is unsurprisingly significant given the large difference in F2 (p < .001). Each of these findings is in line with the data from Escudero et al. (2009). However, in terms of duration (p = .212) and IntDiff (p = .429), [i] and [ʊ] are not significantly different in word-final atonic position. Having established the parameters of BP [i] and [ʊ] against which the experimental participants’ productions will be measured, the discussion now turns to Spanish vowel quality.

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3 An example of mispronunciation would be a token such as *male* produced as [*ma.fe*], where the consonant in the final CV syllable was incorrect.

4 Standard deviations are not presented here because they can only be calculated from raw averages, and not from EMMs. Instead, standard error is presented throughout.

5 While Escudero et al. (2009)’s acoustic description of BP vowels includes /e/ and /o/, data are only presented for tonic vowels flanked by consonants, and are therefore not used here as a comparison.
6.2.2 Spanish Control Vowel Quality

From the 135 tokens recorded from the Spanish sample \((n=9)\), 120 were submitted for full analysis. Only one was excluded from analysis due to complete devoicing, and another 10 were excluded because of mispronunciation. A total of four tokens had unstable formant structure and only duration and IntDiff values were analyzed. Table 6-2 outlines the five metrics used to analyze the quality of Spanish /e/ and /o/. While the control participants were native Spanish speakers of a wide range of varieties, including Venezuela (Caracas), Spain (Asturias and Madrid), Colombia (Bogotá), El Salvador (San Miguel), the Dominican Republic (Santiago), and Cuba (Havana) and /e/ and /o/ F2 have been found to vary across dialects (e.g. Chládková, Escudero, & Boersma, 2011) the F1, F2, and F2-F1 values presented here are within the ranges reported in Chládková et al. As a visual representation of the F1 and F2-F1 values, Figure 6-2 illustrates the SP control productions. While there is no significant difference between /e/ and /o/ in terms of height (F1) \((p = .284)\), there is a significant difference in terms of frontness (F2) \((p < .001)\) and therefore F2-F1, as well \((p < .001)\). Similarly to BP, neither duration \((p = .428)\) nor IntDiff \((p = .068)\) vary significantly between the front and back vowels.

6.2.3 A Comparison of BP and Spanish Vowels

Having presented the parameters with which the experimental participants will be compared, these metrics will be examined cross-linguistically for significant differences. The learning task for the L3 BP learners will then be outlined in terms of changes to vowel quality that differ between Spanish and BP, as well as predictions for the shape that potential modifications to the Spanish metrics might take.

Tables 6-3 and 6-4 summarize a comparison of the five measurements taken in each language, and Figure 6-3 serves as a visual comparison of the vowel space occupied by /e/ and /o/ in Spanish and BP. An MM revealed a significant Language*Vowel interaction for F1 \((F(1, \ldots))\).
265.56) = 12.065; p = .001), and post-hoc analysis revealed Spanish /e/ (p < .001) and /o/ (p = .025) have significantly higher F1 values. As suggested by the vowel chart (Figure 6-3), they are thus significantly lower than BP /e/ and /o/. An F2 analysis also revealed a significant Language*Vowel interaction (F (1, 265.97) = 7.323; p = .007). BP /e/ has a higher F2 value than Spanish and therefore is more front; the difference in F2 for BP and Spanish /o/ was not significant. Similar results were found for F2-F1; a Language*Vowel interaction (F (1, 265.45) = 18.06; p < .001) indicates that the F2-F1 range is larger for BP /e/ than for Spanish (p < .001).

Turning to duration, a Type III Tests of Fixed Effects did not indicate a significant Language*Vowel interaction (F (1, 291.44) = 1.034; p = .310), although post-hoc analysis suggests a difference approaching significance with /o/ longer in BP (p = .052). Considering the findings in Escudero et al. (2009) that favor vowel-intrinsic duration (Lehiste, 1970) in which higher vowels are shorter, a lack of significant difference between the lower Spanish vowels and higher BP vowels was not expected. However, speaking rate was not analyzed, and it could be that the Spanish speakers evidence a faster speaking rate than BP, washing out the durational differences found between mid and high vowels. Finally, Language*Vowel was approaching significance for IntDiff (F (1, 291.27) = 3.831; p = .051), and post-hoc analyses were not significant. Considering that BP vowel reduction as according to Crosswhite (2001, 2004) is a reduction in prominence (in this case, prominence = sonority), and that Parker (2008) posits that intensity is the sole acoustic correlate of sonority, these results do not support Parker’s findings.\(^6\) However, it is possible that the BP IntDiff data, as well as the duration data, were skewed by the number of tokens that were excluded due to a lack of voicing or stable formant structure and additional BP control data will be collected to determine whether this might be the case.

Following from the results presented here comparing BP and Spanish, /e/ and /o/ F1 and /e/ F2

\(^6\) See Chapter 3 for discussion.
are what differentiate Spanish fully-realized vowels from BP reduced vowels in unstressed word-final position. These differences translate to higher and therefore less sonorous BP vowels.

6.2.4 The L3 Learning Task and Potential Modifications to Spanish Vowels

Assuming transfer of the Spanish system at the initial stages of L3 BP and considering the control data reviewed in the previous sections, recall from Chapter 3 that convergence on the BP [ɪ] and [ʊ] target outputs with an input of /e/ and /o/, respectively, requires demotion of the feature faithfulness constraints *MID, MAX[-high], and DEP[+high], all of which correspond to a decrease in F1, i.e., increased height, of both /e/ and /o/. Additionally, F2 /e/ will have to increase, since reduced [ɪ] is more front than [e].\(^7\) Duration and IntDiff are not expected to change, given the lack of significant differences between the BP and SP control data.

Considering the review of the attrition literature in Chapter 2, it is proposed that learners that evidence target-like production of [ɪ] and [ʊ] in BP might experience influence of these vowels on their Spanish mid vowels. As the discussion turns to the experimental Spanish data, special attention will be paid to the comparison of the experimental groups with the control group in terms of F1 (/e/ and /o/) and F2 /e/). A significant decrease in F1 values and an increase in F2 for /e/ could be indicative of reliance on the BP system. Should this evidence be present, the next step will be to determine whether this influence affects speakers that are early acquirers of Spanish, late acquirers of Spanish, or both. Given the perception results presented in Chapter 5, the strong version of the PPH (i.e., that the Spanish mental representation of late acquirers is modified, while that of early acquirers is not) is not supported. The RT data do not support the weak version of the PPH, either. At this juncture, it remains to be seen whether the production

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\(^7\) These constraints will result in the correct target output given the inventory, as long as *UNSTRESSED/i, u is also promoted in BP, since the reduced constraint is the only one that will not be fatally violated. Moving forward, it will be of interest to determine the representation of an interlanguage ranking that yields target height and target-deviant F2.
data support a weak version of the PPH, or whether L3 BP acquirers do not demonstrate BP vowel quality in their Spanish word-final unstressed production, regardless of age of acquisition of Spanish.

6.2.5 Experimental BP Vowel Quality

From the 660 tokens recorded by 44 experimental participants, 543 items were submitted for full acoustic analysis. 46 items were excluded from analysis because of mispronunciation, and 12 were excluded due to complete devoicing. 59 tokens had unstable formant structure and only duration and IntDiff values were analyzed.

6.2.5.1 F1 and F2

Tables 6-5 and 6-6 present mean F1, F2, and F2-F1 values for BP /e/ and /o/, respectively, across the control group and six experimental groups. The F1 and F2-F1 values are presented in a vowel chart in Figure 6-5. The MM run for F1 did not yield a significant Group*Vowel interaction ($F (6, 649.66) = 10.70; p < .446$). After reducing the model, Group was not found to have a significant effect on F1 values ($F (6, 50.53) = 1.626; p < .159$). Therefore, all of the experimental groups evidenced similar F1 values for both /e/ and /o/ when compared with the BP controls. The F2 analysis resulted in a significant Group*Vowel interaction ($F (6, 649.66) = 10.70; p < .001$), as did the F2-F1 analysis ($F (6, 649.20) = 9.33; p < .001$). Post-hoc examination revealed that the BP controls have significantly lower F2 /e/ values than the heritage speaker intermediate BP group ($p = .036$) and the heritage speaker advanced BP participants ($p = .016$), and a smaller F2-F1 range than the HS advanced BP group ($p = .012$). Therefore, these participants are producing hybrid phones with target F1 values and non-target F2 values. As clearly illustrated in Figure 6-5 by the heritage speaker advanced BP /e/, the hybrid approximates [i] in terms of frontness. The heritage speaker intermediate BP /e/ is not as front because of a higher (although not significantly so) F1 value, which closes the gap slightly in the F2-F1 range.
It is possible that the heritage speaker F2 values can be explained by equivalence classification (e.g. Flege, 1987), a phenomenon in which learners map phones from the L2 (in this case, the L3) that are similar to L1 phones onto existing categories from their L1. In this case, the heritage speaker learners could have mapped BP [i] onto Spanish [i], with /i/ as the input, rather than /e/. If this is so, it is not impossible that the learners have successfully raised the F1 to approximate the relatively lower [i], but are still in the process of adjusting the frontness of the vowel, resulting in hybrid vowel productions that have the frontness of [i] but the height of target [i]. It is also possible that the means reflect variable rather than hybrid outputs, in which case [i] alternates with [i]. In terms of OT, it is possible in such a case that *UNSTRESSED/i,u is still gradually being promoted to the first stratum and overlaps with *UNSTRESSED/(i,i,o). Closer analysis of individual productions in the future will provide more insight.

The possibility of the heritage speaker groups’ results being indicative of acquisition still in progress is supported by the analysis performed with Immersion as a variable. While there were no significant Group*Vowel*Immersion interactions in terms of F1 or F2, vowels analyzed from heritage speaker intermediate BP learners tested in an immersion setting had a significantly smaller F2-F1 range (Immersion*Group*Frontback (F (5, 488.09) = 6.288; p < .001; post-hoc p < .001) than those of learners that were tested in the US (all of whom had had between one and two semesters of formal BP study, and no immersion experience). It remains unclear as to why only the heritage speaker bilinguals would evidence higher F2 values and/or F2-F1 ranges, and without longitudinal data to inform the acquisition process, this proposal is merely suggestive. Whatever the reason for the difference in F2 values, it is clear that the heritage speaker learners have not fully converged on the BP target. However, significantly higher F2 values in the

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8 Again, this assumes transfer of the Spanish system at the initial stages of L3 BP.
Spanish data for these groups could still indicate influence from the interlanguage rankings of the heritage speakers. Having established that the L3 BP learners have largely approximated BP control F1, F2, and F2-F1 values, duration and IntDiff data will now be reviewed.

### 6.2.5.2 Duration

Recall that the comparison of BP with Spanish control data did not yield any statistically significant differences between languages for duration (measured as the onset and offset of voicing of the vowel). Mean BP duration by vowel type is reported in Tables 6-7 (\(\text{ /e/ }\) means) and 6-8 (\(\text{ /o/ }\) means), and in the bar graph in Figure 6-6. Given the lack of difference in duration between BP and Spanish, it is not surprising that Group*Vowel was not significant \((F(6, 729.90) = 1.2; p = .305)\). The model was refit without the Group*Vowel interaction, and the analysis returned Group (Table 6-9 and Figure 6-7) as an insignificant main effect \((F(6, 50.82) = 1.981; p = .086)\). Further examination determined that there was no effect for immersion \((\text{Immersion*Group*Vowel } (F(5, 546.32) = .849; p = .515); \text{Immersion*Group } (F(4, 40.89) = .266; p = .898); \text{Immersion } (F(2, 53.23) = .237; p = .790)\); that is, the experimental groups all produced vowels with durations similar to those of the BP controls, independent of vowel type or where the participants were tested.

### 6.2.5.3 Relative intensity

As is the case with duration, IntDiff was not found to differ significantly between Spanish and BP vowels, and the L3 BP participants’ data are in line with that of the BP controls. Means by vowel type are presented in Tables 6-10 and 6-11 and Figure 6-8.

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9 In the case of duration and IntDiff, it was appropriate to reduce the model to exclude the Group*Frontback interaction, since BP control duration and IntDiff did not vary significantly by vowel type.
Group*Vowel was not significant (F (6, 729.78) = 1.35; p = .234). The model was refit without the Group*Vowel interaction, and the analysis returned Group (Table 6-12 and Figure 6-9) as an insignificant main effect (F (6, 51.0) = .72; p = .634). When analyzed with Immersion factored in, the data showed that there was no significant effect (Immersion*Group*Vowel (F (5, 546.39) = 2.115; p = .062); Immersion*Group (F (4, 40.97) = .845; p = .505); Immersion (F (2, 55.287) = 1.071; p = .350). Just as in the case of duration, the experimental groups all produced vowels with intensity similar to those of the BP controls, independent of testing location or vowel type.

After reviewing the cross-sectional experimental data and their comparison with the BP control data, the discussion now turns to a report of the case study data and the participant’s acquisition of L3 BP /e/ and /o/ as compared with the confidence intervals generated from the MMs run on the BP control data and that of his peer group, the L1 English advanced BP learners.

6.2.6 Case study BP Vowel Quality

Recall that Draco’s BP foreign accent rating was 4.75 out of seven, and his proficiency test score was 89/100.

6.2.6.1 F1, F2, and F2-F1

Draco’s mean F1, F2, and F2-F1 values are presented in Table 6-13, and these values are compared with the BP control and L1 English advanced BP means in the vowel chart in Figure 6-10. Draco’s /e/ F1 of 340Hz falls just under the 95% confidence intervals of the controls (354Hz-443Hz) and L1 English advanced BP group (370Hz-463Hz), with minimal variation. Therefore, the height of the vowel is slightly higher than the controls’ and learners’. His F2 and therefore his F2-F1 range fall well outside of both groups’ confidence intervals (BP control: F2 = 2234Hz-2426Hz, F2-F1 = 1841-2031; L1 English advanced BP group: F2 = 2176Hz-2401Hz; F2-F1 = 1761Hz-1984Hz). These average differences result in an /e/ that is slightly higher than BP [ɪ] and farther back in the vowel space. While the height is more similar to BP /e/ than to
Spanish /e/, his F2-F1 range falls within the confidence interval of the Spanish control group (1550Hz-1701Hz).

Turning to back /o/, the average F1 of 362Hz falls below the 95% confidence intervals of the controls (394Hz-485Hz) and L1 English advanced BP group (370Hz-463Hz), meaning Draco’s productions are again slightly higher in the vowel space than the target BP segment. However, his F2 (979Hz) and F2-F1 range (617Hz) fall within both groups’ confidence intervals (BP control F2 913Hz-1101Hz, F2-F1 463Hz-651Hz; L1 English advanced BP 866Hz-1086Hz; F2-F1 427Hz-646Hz) and therefore his /o/ productions are similar to theirs in backness. That is, they are less back than the Spanish control /o/.

To summarize, Draco’s front vowels are higher than the BP target with respect to F1 (height), and the average F2 remains Spanish-like after 11 weeks of BP exposure. Draco’s back vowels are similar to those in BP with respect to F2 (backness), but evidence lower F1s and therefore more height than is to be expected in BP. Thus, while his vowel height is not Spanish-like, it is also higher than the BP targets. As was speculated in the case of the HS learners’ front /e/, it is conceivable here that Draco initially mapped BP [ɪ] and [ʊ] onto Spanish /i/ and /u/, rather than /e/ and /o/, and is in the process of lowering the F1. However, this is an empirical question. While the BP targets have not fully been converged on, there are qualities of Draco’s BP vowels that could potentially influence his Spanish word-final vowel production. Such influence is predicted to take the form of one or more of the following: a) a significant reduction in F1 in Spanish /e/, b) a significant reduction in F1 in Spanish /o/, c) a larger F2-F1 range for back /o/.

6.2.6.2 Duration and IntDiff

While the BP and Spanish control data did not point to differences in duration and IntDiff, it is of note that Draco’s /e/ duration surpasses that of the controls (121ms-164ms), but is
in line with his peer group (144ms-198ms). Given the lack of statistically significant differences between the experimental and control participants, the fact that he falls within the confidence interval of the L1 English advanced BP group for /e/ and within the confidence intervals of both groups for /o/ (control: 131ms-172ms; L1 English advanced BP: 133ms-180ms) indicates that he is performing similarly to the experimental and control participants. With respect to IntDiff, his averages align with the confidence intervals of the controls (/e/: 10.9dB-15.0dB; /o/: 10.5dB-14.5dB) and L1 English advanced BP group (/e/: 10.0dB-14.8dB; /o/: 10.0dB-14.7dB).

6.2.7 Interim Summary: Acquisition of Word-Final BP Vowels

6.2.7.1 Experimental participants

All of the experimental groups have converged on the L3 BP /o/ target [ʊ] in terms of F1, F2, and F2-F1 values, and the L1 Spanish and L1 English groups also demonstrate F1, F2, and F2-F1 values consistent with those of BP control [ɪ] and [ʊ]. Assuming the learners initiated L3 acquisition with a copied Spanish ranking (Table 6-14) in which all feature faithfulness constraints outrank the family of prominence reduction constraints introduced in Chapter 3, these groups appear to have successfully reranked the sets of constraints to yield the BP word-final unstressed inventory. Crucially, they have demoted MAX[-high], DEP[+high], *MID, and MAX[+low], and promoted *UNSTRESSED/æ, a, a, *UNSTRESSED/e, a, *UNSTRESSED/e,o, and *UNSTRESSED/i,u (Table 6-15). Should these groups of learners evidence BP influence in terms of F1 and/or F2 values on their Spanish systems, it is conceivable that this is due to accessing their target-like L3 BP constraint rankings and influence is predicted to surface in terms of a) higher F1 values for /e/ and /o/ (lower in the vowel space than the Spanish controls’ [e] and [o]) and b) higher F2 /e/ values (more front than Spanish [o]).

With respect to the HSers, it appears that acquisition of BP [ɪ] is still in progress and productions have not yet converged on the target backness of the vowel. In terms of constraint
ranking, it is possible that there is overlap of one or more constraints in the process of promotion/demotion, causing hybrid and/or variable outputs. If it is the case that these learners have mapped [i] onto /i/, variable [i] ~ [i] outputs could present as a result of *UNSTRESSED/i,u and *UNSTRESSED/(1,0) straddling Stratum 1 and Stratum 2 (Table 6-16). Table 6-17 demonstrates that these variable outputs with an F1 significantly higher than the Spanish F1 frequency are both potential winning candidates for an input of /e/. Thus, in the case that a learner accesses the BP ranking while in Spanish mode, higher, more BP-like outputs would be possible. It will be of interest going forward to pursue this as an empirical question.

6.2.7.2 Case study

Draco’s front and back vowels are higher than the BP control vowels but his F2-F1 value is Spanish-like. His back vowels evidenced target-like F2 but lower F1 values than expected in BP, resulting in a vowel that is higher than BP [ʊ]. In spite of a need for further analysis of these target-deviant productions to better understand the acquisition process in terms of constraint reranking, it is clear that MAX[-high] and DEP[+high] have been demoted, allowing front and back vowels to surface in his L3 BP system that are significantly higher than that of the Spanish controls. Based on the observations of Draco’s BP vowel quality and assuming an L3 constraint ranking that minimally consists of demoted MAX[-high] and DEP[+high] to Stratum 2, it is predicted that evidence of potential BP influence on his Spanish production will take the form of a higher /e/ (lower F1, but not higher F2 or F2-F1), and a higher (lower F1) and less back /o/ (larger F2-F1).

6.2.7.3 Revisiting predictions

In the discussion of the L3 learning task (Section 3.3.2), it was predicted that L1 Spanish learners would be slower than L2 Spanish learners to acquire BP vowel reduction (i.e., to demote relevant feature faithfulness constraints and promote relevant prominence reduction constraints)
given the relatively entrenched nature of their early-acquired system. Similarly, it was predicted that L2 Spanish learners would be comparably faster than L1 Spanish learners to demote/promote relevant constraints in BP 1) because their Spanish system is not as entrenched and 2) due to possible facilitation from their L1 English system, which exhibits a similar pattern of vowel reduction. Given that the vowel quality of the L1 English and L1 Spanish groups did not differ from that of the BP controls regardless, there is no evidence that age of acquisition (AoA) of Spanish is a significant predictor of rate of acquisition of L3 BP word-final vowels.

Having summarized the L3 BP acquisition data as they compare with the BP controls, predicted acoustic patterns of BP influence on the participants’ Spanish productions, and addressed the data as they relate to the predictions outlined in Chapter 2, the experimental Spanish production data will now be presented and analyzed for evidence of influence. Recall from the presentation of possible outcomes of the current study (Chapter 2) that evidence of such influence could stem from either modification of the Spanish system or issues of inhibitory control, although the perception results in Chapter 5 do not provide evidence in support of changes to the Spanish mental representation or effects on phonological processing during speech perception. This leaves the possibility that any observed influence on the Spanish system could be due to failure to suppress access to the L3 BP ranking during phonological processing during speech production.

6.2.8 Experimental SP Vowel Quality

From the 675 tokens recorded by 45 experimental participants, 603 items were submitted for full acoustic analysis. 45 items were excluded from analysis because of mispronunciation, and four were excluded due to complete devoicing. 23 tokens had unstable formant structure and these tokens were only analyzed for duration and IntDiff.
6.2.8.1 F1 and F2

Tables 6-18 and 6-19 present mean F1, F2, and F2-F1 values for Spanish /e/ and /o/, respectively, across the control group and six experimental groups. The MM run for F1 yielded a significant Group*Vowel interaction \( (F(6, 665.94) = 4.890; p < .001) \), but significance stemmed from the difference between front and back F1 values that each group made and not from differences between groups according to vowel type. After reducing the model, Group was not found to have a significant effect on F1 values \( (F(6, 47.149.) = 4.890; p = .338) \). Therefore, all of the experimental groups evidenced similar F1 values for both /e/ and /o/ when compared with the SP controls. The F2 analysis resulted in a significant Group*Vowel interaction \( (F(6, 665.82) = 11.266; p < .001) \), although post-hoc analysis did not reveal any significant differences between the SP control F2s and any of the experimental groups. Similarly to the F1 analysis, a Group*Vowel interaction was significant for F2-F1 \( (F(6, 665.82) = 7.666; p < .001) \) due to vowel distinctions made by the groups. When the model was refit, Group was not revealed to have a significant effect on F2-F1 \( (F(6, 718.0) = .467; p = .833) \).

Comparing the experimental groups against one another with Immersion as an independent within-subjects variable, some significant differences were found, but such results should be taken with caution, given the disparity in some of the sample sizes. The Immersion*Group*Vowel interaction was significant for F1 \( (F(5, 547.39) = 3.305; p = .006) \), and it was found that the single HS advanced learner in an immersion setting had higher F1 values for /e/ than those that were tested in the US \( (n = 4) \). The F2 Immersion*Group*Vowel interaction was also significant \( (F(5, 547.66) = 4.157; p < .001) \). The HS intermediate F2 values were higher for /e/ in the US \( (n = 1) \) than those in Brazil \( (n = 7) \), and lower for the L1 English advanced BP learner in Brazil \( (n = 1) \) than his peers tested in the US \( (n = 4) \). Finally, F2-F1 was also significantly different depending on immersion context \( (Immersion*Group*Vowel (F(5, \ldots)) \).
547.69) = 2.237; p = .049). Both the HS intermediate (n = 8) and L1 English intermediate BP learners (n = 4) tested in the US evidenced a larger F2-F1 range for /e/ (p = .026; p = .009) than their counterparts in Brazil (n = 6; n= 5, respectively), meaning that their front vowels are more front, but not necessarily less Spanish-like.

In sum, none of the experimental groups demonstrated influence of BP [ɪ] or [ʊ] on productions of Spanish [e] or [o] that deviated from the Spanish control norm with respect to F1, F2, or F2-F1. While some differences were found according to whether the learners were tested in Brazil or the US, the sample sizes were uneven and a larger-scale study will be necessary to confirm any of the findings here.

6.2.8.2 Duration

Mean SP duration by vowel type is reported in Tables 6-20 (/e/ means) and 6-21 (/o/ means), and in the bar graph in Figure 6-12. Considering the similarity in duration between BP and Spanish, it is not surprising that Group*Vowel was not significant (F (6, 689.93) = .928; p = .474). The model was refit without the Group*Vowel interaction, and the analysis returned Group (Table 6-22 and Figure 6-13) as a significant main effect (F (6, 47.14) = 2.551; p = .032). However, the post-hoc did not indicate any significant differences, suggesting a possible Type I error. An examination of the effect of immersion on duration returned a significant Immersion*Group*Vowel interaction (F (5, 569.66) = 3.513; p = .004). The immersed L1 Spanish intermediate BP speaker evidenced longer durations (p = .014) than those tested in the US (n = 4). However, given that this result was based on one speaker, the analysis was run a second time without the Vowel effect (F (4, 34.20) = .863; p = .496), and reduced once more with only Immersion as a fixed effect (F (2, 84.05) = 5.773; p = .004). It seems that while duration is not conditioned by immersion within groups, the learners that were tested in Brazil have shorter duration overall.
6.2.8.3 Relative intensity

As is the case with duration, the IntDiff control data did not differ significantly between Spanish and BP, and the experimental participants’ Spanish data is in line with that of the Spanish controls. Means by vowel are presented in Tables 6-23 and 6-24 and Figure 6-14. No significant interactions were found (Group*Vowel (F (6, 689.80) = 1.162; p = .325), and no significant effect was found for Group, either (F (6, 47.15) = 1.170; p = .338). Overall means are presented in Table 6-25 and Figure 6-15. Finally, there were no significant differences in IntDiff between learners that were tested in Brazil and those that were tested in the US (Immersion*Group*Vowel (F (5, 569.71) = 1.063; p = .380); Immersion*Group (F (4, 34.132) = 2.177; p = .092); Immersion (F (2, 82.93) = .288; p = .750)).

Taken together, all of the data across the five dependent variables measured indicate that the experimental groups’ Spanish [e] and [o] do not evidence influence of BP [i] or [ʊ] in terms of height, backness, duration of voicing, and relative intensity to the extent that any of these variables differs significantly from those of the Spanish controls. However, because it was not possible to observe the learners’ Spanish prior to BP exposure, it is plausible that there have been changes, but that they have not been drastic enough to differ statistically. With that in mind, the discussion continues with a report of the case study data, which do allow observation of the case study participant’s Spanish prior to BP exposure and after. Spanish data were collected from Draco at the onset of BP acquisition, and again 11 weeks later. In the case that there is no evidence of change, his data will support the cross-sectional data. However, if paired-samples t-tests reveal statistically significant changes in the form of lower F1 frequencies and/or a larger /o/ F2-F1, it is possible that Draco is unable to fully suppress his L3 BP system when speaking Spanish. Such an outcome would warrant additional research to determine whether any
observable changes are evidenced in native Spanish systems, as well, or if a failure to suppress the L3 BP system is maturationally conditioned.

6.2.9 Case Study SP Vowel Quality

In Chapter 4, it was reported that Draco qualified for the study with an average foreign accent rating of 6.06 on a scale of one to seven and a written proficiency score of 92 out of 100. After a brief review of his baseline Spanish data as it compares to the Spanish controls, the post-BP data will be presented first in comparison with the Spanish control data confidence intervals, followed by a direct comparison of the data sets collected prior to and during BP acquisition.

6.2.9.1 Baseline Spanish data

Table 6-26 outlines the mean values and standard deviations of Draco’s Spanish vowel quality at the onset of BP acquisition, and Figure 6-16 plots his vowels against those of the Spanish controls. Looking at /e/, while Draco’s pre-BP F1 (500Hz) is slightly lower than the control confidence interval (518Hz-600Hz), it is within the range of the L1 English advanced BP group (475Hz-561Hz), whose F1 values did not differ significantly from those of the control group. His F2 (1775) and F2-F1 (1275Hz) is well below the ranges of the controls (2105Hz-2261Hz; 1550Hz-1771Hz), meaning his baseline Spanish [e] is farther back in the vowel space. It is therefore possible that without having access to his baseline data, a post-BP increase to his /e/ F2, even one of several hundred Hz, would still fall within the control range and such BP influence could be overlooked. An issue such as this highlights the importance of longitudinal data for the testing of empirical questions of this nature.

As reflected in Figure 6-16, Draco’s back vowel occupies a nearly identical space to that of the Spanish controls. His F1 of 563Hz falls within the control confidence interval (506Hz-584Hz), as does the F2 frequency of 967Hz (confidence interval: 908Hz-1060Hz), and the F2-F1 of 404Hz (confidence interval: 371Hz-519Hz).
Draco’s /e/ and /o/ duration measurements average 156ms and 145ms, respectively. The length of vowel voicing falls above the range of the Spanish control confidence intervals (/e/ 101ms-138ms; /o/ 97ms-134ms). However, his duration is in line with the L1 English advanced BP group (/e/ 138ms-177ms; /o/ 129ms-167ms), whose durations were not different than those of the controls. Finally, the relative intensity of the word-final vowels also aligned with the control IntDiff results. The average IntDiff for /e/ was 14.3dB (confidence interval: 9.6dB-14.3dB), and for /o/ was 12.7dB (confidence interval: 10.8dB-15.5dB).

In summary, with the exception of the F2 frequency for /e/, Draco’s pre-BP data falls within the ranges of the Spanish control data. Taken in tandem with his foreign accent rating and proficiency test scores, Draco qualifies as a near-native speaker of Spanish at the onset of BP acquisition.

6.2.9.2 Post-BP Spanish data

Comparison with Spanish controls. Table 6-27 delineates the post-BP Spanish means for the five dependent variables measured, and Figure 6-17 plots Draco’s post-BP vowels against the Spanish control vowels. Draco’s post-BP /e/ has an F1 that falls below the range of both the controls and the L1 English advanced BP learners, indicating that his front vowels are now higher than the Spanish controls’. His F2 and F2-F1 continue well outside of the control confidence interval, and he again produces front segments that are farther back in the vowel space. Post-BP /o/ also falls outside of the Spanish confidence intervals in terms of F1 and F2-F1, meaning that his back vowels are both higher and less back than those of the Spanish controls.

Following from the Constraint Fluctuation Hypothesis (Goodin-Mayeda et al., 2011), it was predicted that because Draco had successfully demoted feature faithfulness constraints necessary to yield /e/-[i] and /o/-[o] outputs, that accessing the L3 BP ranking during Spanish
production could result in influence on the outputs of Spanish /e/ and /o/ inputs. Based on Draco’s BP acquisition pattern, potential changes were predicted to take the form of lower F1 values, resulting in higher vowels, and in an expansion of the F2-F1 range for /o/, resulting in a vowel that is less back. Both of these predictions were born out: While pre-BP F1 values fell within control ranges, post-BP values were lower, resulting in higher vowels. Moreover, the pre-BP data evidenced a native-like F2-F1 range for /o/, while post-BP data points to a range above that of the control. Thus, in comparing each set of data separately with the Spanish control 95% confidence intervals, it would seem that, unlike his peer L1 English advanced BP group, Draco is producing vowels that have been influenced by his acquisition of L3 BP. To confirm, results from paired-samples t-tests directly comparing the pre- and post-BP data are reported next.

**Pre- and post-BP comparison.** Tables 6-28 and 6-29 outline the pre-and post-BP measurements, and Figure 6-18 plots Draco’s pre- and post-BP Spanish vowels alongside the Spanish and BP control vowels. Paired-samples t-tests comparing data from the two testing sessions were run for each of the five measurements. The results of the F1 comparison were statistically significant overall (p < .001) as well as for the front and back conditions (p < .001, p = .009, respectively), confirming that Draco’s F1 values have lowered and his vowels have raised after 11 weeks of BP acquisition. Changes in F2 were not significant (/e/ p = .658; /o/ p = .240), nor was the difference in /e/ F2-F1 (p = .935), which supports the post-BP comparison with the Spanish control data. Also in line with the comparison in the previous section, a significant change was found in the F2-F1 range for /o/ (p = .003), indicating that his back vowel is now slightly less back. Significant differences were also revealed in the pre- and post-BP duration and IntDiff, which were unexpected given the lack of difference between the Spanish controls and the experimental groups. Draco’s post-BP duration increased (p = .036), and IntDiff
decreased (p = .010). Given the similarity in duration and IntDiff found between the SP and BP controls, it is not certain as to why these changes might have occurred. Lastly, it is of note that a post-BP speech sample was submitted to a foreign accent rating by the same group of native-speaker raters that rated his pre-BP speech sample. While the pre-BP FAR was 6.06 out of 7.00, the post-BP average FAR was 4.00 out of 7.00, and the decrease of 2.06 was significant (p < .001).

Summing up, the comparison of Draco’s BP data with the Spanish 95% confidence intervals as well as the comparison of his pre- and post-BP acoustic and FAR data indicate changes to his Spanish productions that are consistent with the predictions made based on his BP acquisition patterns. Specifically, both of Draco’s vowels have raised, and the back vowel has become less peripheral, reducing the sonority of his word-final unstressed vowels.

6.2.10 Discussion and Summary

Throughout this chapter, the data have demonstrated that the learners tested (with exceptions where noted) have successfully acquired L3 BP word-final unstressed [ɪ] and [ʊ]. The L1 English and L1 Spanish groups have converged on the target BP ranking, and the HS learners evidence an interlanguage ranking that is not yet target-like but yields outputs that share acoustic characteristics of the BP outputs. Establishment of acquisition of the L3 BP constraint ranking is a necessary precursor to the focus of the study, which is the nature of regressive transfer on the Spanish system. However, BP influence, in this case a lower F1 value and larger F2-F1 range for /o/, is absent from the Spanish acoustic data analyzed for all six of the experimental groups, regardless of age and context of acquisition or BP proficiency. Interestingly, the case study data tell a different story, in which the predicted changes in F1 and in the F2-F1 range for /o/ did

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10 Front and back vowel data was collapsed, since the Spanish control data did not reveal statistically significant differences for vowel type.
occur, and the participant’s overall foreign accent rating decreased significantly in terms of nativelikeness. Given the aggregate nature of the cross-sectional analysis, the results could be obscuring individual variation of the type that is of interest to the present study, and that is shown as possible by the case study data. In the future, it will be of value to compare individual means with the control confidence intervals, as was done with Draco’s data, to determine whether other individuals have F1 and /o/ F2-F1 values that fall outside of the control confidence intervals.

The PPH argues that phonological systems acquired in adulthood are more vulnerable to influence from a third language than systems acquired during early childhood. As presented first in Chapter 2 and addressed further in the discussion of the perception experiment results in Chapter 5, there were three proposed possible outcomes. Based on the perception results, the third possible outcome, i.e., differences between L1 and L2 groups at the levels of perception and production, was ruled out. Each of the two remaining possible outcomes is reviewed here in light of the perception results taken together with the experimental and case study production results.

6.2.10.1 Possible outcome 1

The first possible outcome was a lack of statistically significant differences between groups in the perception and production data. This outcome would not support the PPH because evidence of such an outcome would suggest that learners’ phonological systems are equally vulnerable (or impervious) to the influence of a third phonological system at the levels of mental representation and processing, regardless of age or context of acquisition. Given the lack of differences in the Spanish control productions when compared with the experimental groups in conjunction with the lack of significant perception and RT results, comparable stability in the face of L3 acquisition supports this outcome and therefore does not support the PPH. However,
the case study data contradict the L1 English advanced group data, as there were no changes between Draco’s pre- and post-BP perception data or RT, but there were significant changes in production. Nevertheless, longitudinal data from L1 Spanish learners (and additional L1 English data) will be needed to compare with the case study data before any conclusions are drawn regarding this outcome.

6.2.10.2 Possible outcome 2

The second proposed outcome was that there would be a lack of statistically significant differences in the L1 and L2 Spanish perception data, but there would be differences across the groups’ RT and/or production data. As mentioned in earlier chapters, this outcome does not support the PPH in its strong form, but instead supports differences in terms of stability at the level of processing, rather than at the level of mental representation. In this case, it was posited that RT and/or production differences found between L1 and L2 speakers could be the result of inhibitory control limitations, considering research that reports superior inhibitory control in the dominant language by late L2 learners, and an early bilingual advantage (e.g. Bialystok, 2009, 2010; Hernández, Costa, Fuentes, Vivas, & Sebastián-Gallés, 2010). Once a learner has developed a separate target-like (or perhaps even partially target-convergent, as in the case of the heritage speakers and case study participant in this study) phonological grammar in the L3, this grammar is activated along with the rest of the speaker’s grammars when the speaker is in Spanish mode (e.g. Poarch & van Hell, 2013). If it is the case that early bilinguals (i.e., the heritage speakers) and late L2 learners speaking their dominant language (i.e., the L1 Spanish/L2 English speakers) have superior inhibitory control in comparison to late bilinguals speaking their non-dominant language (i.e., the L1 English/L2 Spanish speakers), then it is conceivable that the L3 BP learners with comparably less developed inhibitory control will fail to suppress their L3 BP ranking in Spanish mode more than L1 Spanish speakers, resulting in RT differences.
(processing during speech perception) and/or production differences (processing during speech production).

Prior to analysis of the production data, this outcome (and thus support of the weak form of the PPH) was viable, given the lack of differences in the experimental perception data. It was conceivable that in spite of comparable RTs across groups, the additional processing required during speech production could result in intragroup differences. While the cross-sectional data do not align with this outcome since there were no statistically significant differences in the control and experimental participants’ productions of Spanish [e] and [o], the case study data do, pointing to a failure to suppress the BP grammar during Spanish processing. Therefore, while it does seem to be possible that the addition of a novel phonological system could affect phonological processing during speech production, at least when the languages under observation are typologically related, the data available are not sufficient to determine whether these effects present similarly in L1 and L2 speakers. Considering these conflicting results, longitudinal data with larger sample sizes will be necessary to determine which of these outcomes is best supported. Follow-up examination of Draco’s BP and Spanish production will also help shed light on the permanency of BP influence (see de Leeuw, Mennen, & Scobbie, 2012, for a discussion on the permanency of what they call ‘superficial mutations’), which could conceivably have been compounded by the immersion context. While anecdotal, Draco has communicated that, six months after returning to the US and resuming daily use of Spanish in professional and personal environments while reducing his use of BP, he is not experiencing the same level of BP influence that he was while immersed in Brazil. The issue of the permanency of influence will be further addressed in the next chapter as part of a discussion on the future directions of the research program initiated in this study. Having presented the results of this
project, the major findings reported in Chapters 5 and 6 will be discussed in Chapter 7 in terms of their theoretical implications. The challenges associated with this project and future research that will address these challenges will also be presented.
Table 6-1. BP control /e/ mean F1, F2, F2-F1, duration, and relative intensity (IntDiff).

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Table 6-2. SP control mean F1, F2, F2-F1, duration, and IntDiff.

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Table 6-3. BP and Spanish F1, F2, F2-F1, duration, and IntDiff (/e/).

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<th>SE</th>
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<th>SE</th>
<th>IntDiff (dB)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP</td>
<td>551</td>
<td>29.8</td>
<td>2175</td>
<td>50.8</td>
<td>1625</td>
<td>53.2</td>
<td>123</td>
<td>12.2</td>
<td>11.8</td>
<td>1.3</td>
</tr>
<tr>
<td>BP</td>
<td>394</td>
<td>19.9</td>
<td>2330</td>
<td>47.9</td>
<td>1937</td>
<td>47.7</td>
<td>142</td>
<td>10.5</td>
<td>13.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Table 6-4. BP and Spanish F1, F2, F2-F1, duration, and IntDiff (/o/).

<table>
<thead>
<tr>
<th></th>
<th>F1 (Hz)</th>
<th>SE</th>
<th>F2 (Hz)</th>
<th>SE</th>
<th>F2-F1 (Hz)</th>
<th>SE</th>
<th>Dur (ms)</th>
<th>SE</th>
<th>IntDiff (dB)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP</td>
<td>541</td>
<td>29.5</td>
<td>977</td>
<td>49.7</td>
<td>442</td>
<td>52.2</td>
<td>121</td>
<td>11.9</td>
<td>12.9</td>
<td>1.3</td>
</tr>
<tr>
<td>BP</td>
<td>450</td>
<td>19.5</td>
<td>1007</td>
<td>47.1</td>
<td>557</td>
<td>46.9</td>
<td>151</td>
<td>10.3</td>
<td>12.5</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Table 6-5. BP /e/ mean F1, F2, and F2-F1 values.

<table>
<thead>
<tr>
<th>Group</th>
<th>F1 (Hz)</th>
<th>SE</th>
<th>F2 (Hz)</th>
<th>SE</th>
<th>F2-F1 (Hz)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>394</td>
<td>19.9</td>
<td>2330</td>
<td>47.9</td>
<td>1937</td>
<td>47.7</td>
</tr>
<tr>
<td>L1 SP int</td>
<td>375</td>
<td>32.4</td>
<td>2553</td>
<td>78.2</td>
<td>2083</td>
<td>58.9</td>
</tr>
<tr>
<td>L1 SP adv</td>
<td>443</td>
<td>37.2</td>
<td>2414</td>
<td>89.7</td>
<td>1970</td>
<td>89.2</td>
</tr>
<tr>
<td>HS int</td>
<td>469</td>
<td>21.2</td>
<td>2560</td>
<td>51.2</td>
<td>2091</td>
<td>50.9</td>
</tr>
<tr>
<td>HS adv</td>
<td>386</td>
<td>36.7</td>
<td>2685</td>
<td>88.5</td>
<td>2299</td>
<td>88.0</td>
</tr>
<tr>
<td>L1 EN int</td>
<td>433</td>
<td>24.5</td>
<td>2517</td>
<td>59.2</td>
<td>2084</td>
<td>58.9</td>
</tr>
<tr>
<td>L1 EN adv</td>
<td>416</td>
<td>23.3</td>
<td>2289</td>
<td>56.2</td>
<td>1873</td>
<td>55.9</td>
</tr>
</tbody>
</table>
Table 6-6. BP /o/ mean F1, F2, and F2-F1 values.

<table>
<thead>
<tr>
<th>Group</th>
<th>F1 (Hz)</th>
<th>SE</th>
<th>F2 (Hz)</th>
<th>SE</th>
<th>F2-F1 (Hz)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>450</td>
<td>19.5</td>
<td>1107</td>
<td>47.1</td>
<td>555</td>
<td>46.9</td>
</tr>
<tr>
<td>L1 SP int</td>
<td>431</td>
<td>24.8</td>
<td>988</td>
<td>78.2</td>
<td>557</td>
<td>77.8</td>
</tr>
<tr>
<td>L1 SP adv</td>
<td>474</td>
<td>38.5</td>
<td>1037</td>
<td>92.6</td>
<td>562</td>
<td>92.3</td>
</tr>
<tr>
<td>HS int</td>
<td>498</td>
<td>20.9</td>
<td>1000</td>
<td>50.5</td>
<td>502</td>
<td>50.9</td>
</tr>
<tr>
<td>HS adv</td>
<td>399</td>
<td>35.6</td>
<td>969</td>
<td>86.2</td>
<td>570</td>
<td>85.6</td>
</tr>
<tr>
<td>L1 EN int</td>
<td>446</td>
<td>34.8</td>
<td>973</td>
<td>59.8</td>
<td>528</td>
<td>59.6</td>
</tr>
<tr>
<td>L1 EN adv</td>
<td>440</td>
<td>38.5</td>
<td>976</td>
<td>55.2</td>
<td>537</td>
<td>54.9</td>
</tr>
</tbody>
</table>

Table 6-7. BP /e/ duration means.

<table>
<thead>
<tr>
<th>Group</th>
<th>Duration (ms)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>143</td>
<td>10.5</td>
</tr>
<tr>
<td>L1 SP int</td>
<td>150</td>
<td>17.4</td>
</tr>
<tr>
<td>L1 SP adv</td>
<td>126</td>
<td>19.7</td>
</tr>
<tr>
<td>HS int</td>
<td>174</td>
<td>11.4</td>
</tr>
<tr>
<td>HS adv</td>
<td>158</td>
<td>19.7</td>
</tr>
<tr>
<td>L1 EN int</td>
<td>132</td>
<td>13.1</td>
</tr>
<tr>
<td>L1 EN adv</td>
<td>169</td>
<td>12.5</td>
</tr>
</tbody>
</table>

Table 6-8. BP /o/ duration means.

<table>
<thead>
<tr>
<th>Group</th>
<th>Duration (ms)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>151</td>
<td>10.3</td>
</tr>
<tr>
<td>L1 SP int</td>
<td>133</td>
<td>17.3</td>
</tr>
<tr>
<td>L1 SP adv</td>
<td>120</td>
<td>19.5</td>
</tr>
<tr>
<td>HS int</td>
<td>175</td>
<td>11.2</td>
</tr>
<tr>
<td>HS adv</td>
<td>141</td>
<td>19.2</td>
</tr>
<tr>
<td>L1 EN int</td>
<td>128</td>
<td>13.1</td>
</tr>
<tr>
<td>L1 EN adv</td>
<td>157</td>
<td>12.1</td>
</tr>
</tbody>
</table>

Table 6-9. Overall duration means.

<table>
<thead>
<tr>
<th>Group</th>
<th>Duration (ms)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>147</td>
<td>51.0</td>
</tr>
<tr>
<td>L1 SP int</td>
<td>142</td>
<td>16.4</td>
</tr>
<tr>
<td>L1 SP adv</td>
<td>123</td>
<td>51.3</td>
</tr>
<tr>
<td>HS int</td>
<td>175</td>
<td>10.6</td>
</tr>
<tr>
<td>HS adv</td>
<td>150</td>
<td>18.3</td>
</tr>
<tr>
<td>L1 EN int</td>
<td>130</td>
<td>12.3</td>
</tr>
<tr>
<td>L1 EN adv</td>
<td>163</td>
<td>11.6</td>
</tr>
</tbody>
</table>
Table 6-10. BP /e/ IntDiff means.

<table>
<thead>
<tr>
<th>Group</th>
<th>IntDiff (dB)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>13.0</td>
<td>1.0</td>
</tr>
<tr>
<td>L1 SP int</td>
<td>10.5</td>
<td>1.7</td>
</tr>
<tr>
<td>L1 SP adv</td>
<td>12.7</td>
<td>1.9</td>
</tr>
<tr>
<td>HS int</td>
<td>12.4</td>
<td>1.1</td>
</tr>
<tr>
<td>HS adv</td>
<td>11.1</td>
<td>1.9</td>
</tr>
<tr>
<td>L1 EN int</td>
<td>13.7</td>
<td>1.3</td>
</tr>
<tr>
<td>L1 EN adv</td>
<td>12.4</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Table 6-11. BP /o/ IntDiff means.

<table>
<thead>
<tr>
<th>Group</th>
<th>IntDiff (dB)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>12.5</td>
<td>1.1</td>
</tr>
<tr>
<td>L1 SP int</td>
<td>9.8</td>
<td>1.7</td>
</tr>
<tr>
<td>L1 SP adv</td>
<td>10.2</td>
<td>1.9</td>
</tr>
<tr>
<td>HS int</td>
<td>11.2</td>
<td>1.1</td>
</tr>
<tr>
<td>HS adv</td>
<td>12.0</td>
<td>1.9</td>
</tr>
<tr>
<td>L1 EN int</td>
<td>14.1</td>
<td>1.3</td>
</tr>
<tr>
<td>L1 EN adv</td>
<td>12.3</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Table 6-12. Overall IntDiff means.

<table>
<thead>
<tr>
<th>Group</th>
<th>IntDiff (dB)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1.0</td>
</tr>
<tr>
<td>L1 SP int</td>
<td>10.1</td>
<td>1.6</td>
</tr>
<tr>
<td>L1 SP adv</td>
<td>11.5</td>
<td>1.8</td>
</tr>
<tr>
<td>HS int</td>
<td>11.8</td>
<td>1.1</td>
</tr>
<tr>
<td>HS adv</td>
<td>11.6</td>
<td>1.8</td>
</tr>
<tr>
<td>L1 EN int</td>
<td>13.9</td>
<td>1.2</td>
</tr>
<tr>
<td>L1 EN adv</td>
<td>12.4</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Table 6-13. Case study mean F1, F2, and F2-F1 values.

<table>
<thead>
<tr>
<th>F1 (Hz)</th>
<th>F2 (Hz)</th>
<th>F2-F1 (Hz)</th>
<th>Dur (ms)</th>
<th>IntDiff (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>/e/</td>
<td>340</td>
<td>1975</td>
<td>1560</td>
<td>181</td>
</tr>
<tr>
<td>/o/</td>
<td>362</td>
<td>979</td>
<td>617</td>
<td>169</td>
</tr>
</tbody>
</table>

166
Table 6-14. L3 BP ranking at the initial stages of acquisition.

<table>
<thead>
<tr>
<th>/libro/</th>
<th>MAX[F]</th>
<th>DEP[+hi]</th>
<th>*Mid</th>
<th>*UNS/a</th>
<th>*UNS/e,o</th>
<th>*UNS/i,u</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>'[li.βr(o)]</em></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6-15. L3 BP ranking, L1 Spanish and L1 English groups.

<table>
<thead>
<tr>
<th>/livo/</th>
<th>MAX [rd]</th>
<th>MAX [-fr]</th>
<th>*UNS a</th>
<th>*UNS e,o</th>
<th>*UNS i,u</th>
<th>MAX [-hi]</th>
<th>DEP [+hi]</th>
<th>*Mid</th>
<th>*UNS (v)</th>
<th>*UNS (1,0)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>'[li.vro]</em></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>'[li.vr(o)]</em></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>'[li.vru]</em></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>'[li.vra]</em></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>'[li.vr(v)]</em></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>'[li.vr(i)]</em></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
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<td></td>
</tr>
</tbody>
</table>

Table 6-16. Possible heritage speaker group BP interlanguage ranking with /i/ input.

<table>
<thead>
<tr>
<th>/padri/</th>
<th>MAX [rd]</th>
<th>DEP [rd]</th>
<th>MAX [+hi]</th>
<th>*UNS a</th>
<th>*UNS e,o</th>
<th>*UNS i,u</th>
<th>MAX [-hi]</th>
<th>DEP [+hi]</th>
<th>*Mid</th>
<th>*UNS (v)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>'[pa.dre]</em></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td><em>'[pa.dr(i)]</em></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td><em>'[pa.dri]</em></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td><em>'[pa.dru]</em></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td><em>'[pa.dr(o)]</em></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td><em>'[pa.dr(v)]</em></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td><em>'[pa.dra]</em></td>
<td></td>
<td></td>
<td>*</td>
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<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>
Table 6-17. Possible heritage speaker group BP interlanguage ranking with /e/ input.

<table>
<thead>
<tr>
<th></th>
<th>MAX [rd]</th>
<th>DEP [rd]</th>
<th>MAX [+hi]</th>
<th>*UNS e,o</th>
<th>*UNS e,o</th>
<th>*UNS (l,u)</th>
<th>MAX [-hi]</th>
<th>DEP [+hi]</th>
<th>*MID</th>
<th>*UNS (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>/'padaɾe/</td>
<td>['padaɾe]</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>['padaɾ(ɪ)]</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>['padaɾi]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>['padaɾu]</td>
<td>*!</td>
<td></td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>['padaɾ(ʊ)]</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>['padaɾ(ə)]</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>/'padaɾa/</td>
<td>!</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td>!</td>
</tr>
</tbody>
</table>

Table 6-18. Spanish /e/ mean F1, F2, and F2-F1 values.

<table>
<thead>
<tr>
<th>Group</th>
<th>F1 (Hz)</th>
<th>SE</th>
<th>F2 (Hz)</th>
<th>SE</th>
<th>F2-F1 (Hz)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>551</td>
<td>29.5</td>
<td>2175</td>
<td>50.8</td>
<td>1625</td>
<td>53.2</td>
</tr>
<tr>
<td>L1 SP int</td>
<td>566</td>
<td>26.3</td>
<td>2146</td>
<td>49.8</td>
<td>1581</td>
<td>48.5</td>
</tr>
<tr>
<td>L1 SP adv</td>
<td>564</td>
<td>36.9</td>
<td>2011</td>
<td>69.9</td>
<td>1448</td>
<td>89.2</td>
</tr>
<tr>
<td>HS int</td>
<td>584</td>
<td>18.0</td>
<td>2167</td>
<td>34.1</td>
<td>1583</td>
<td>33.2</td>
</tr>
<tr>
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<td>29.0</td>
<td>2310</td>
<td>55.0</td>
<td>1715</td>
<td>53.7</td>
</tr>
<tr>
<td>L1 EN int</td>
<td>552</td>
<td>21.9</td>
<td>2058</td>
<td>41.6</td>
<td>1506</td>
<td>40.6</td>
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<tr>
<td>L1 EN adv</td>
<td>533</td>
<td>21.9</td>
<td>2007</td>
<td>41.2</td>
<td>1474</td>
<td>39.7</td>
</tr>
</tbody>
</table>

Table 6-19. Spanish /o/ mean F1, F2, and F2-F1 values.

<table>
<thead>
<tr>
<th>Group</th>
<th>F1 (Hz)</th>
<th>SE</th>
<th>F2 (Hz)</th>
<th>SE</th>
<th>F2-F1 (Hz)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>541</td>
<td>29.5</td>
<td>977</td>
<td>49.7</td>
<td>442</td>
<td>52.2</td>
</tr>
<tr>
<td>L1 SP int</td>
<td>549</td>
<td>26.1</td>
<td>950</td>
<td>49.4</td>
<td>402</td>
<td>48.2</td>
</tr>
<tr>
<td>L1 SP adv</td>
<td>476</td>
<td>36.8</td>
<td>953</td>
<td>69.5</td>
<td>477</td>
<td>67.5</td>
</tr>
<tr>
<td>HS int</td>
<td>539</td>
<td>17.8</td>
<td>985</td>
<td>33.6</td>
<td>452</td>
<td>32.7</td>
</tr>
<tr>
<td>HS adv</td>
<td>490</td>
<td>28.8</td>
<td>972</td>
<td>54.4</td>
<td>481</td>
<td>53.0</td>
</tr>
<tr>
<td>L1 EN int</td>
<td>543</td>
<td>21.4</td>
<td>982</td>
<td>40.4</td>
<td>440</td>
<td>39.4</td>
</tr>
<tr>
<td>L1 EN adv</td>
<td>534</td>
<td>1.5</td>
<td>1023</td>
<td>40.5</td>
<td>498</td>
<td>38.9</td>
</tr>
</tbody>
</table>
Table 6-20. Spanish /e/ duration means.

<table>
<thead>
<tr>
<th>Group</th>
<th>Duration (ms)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>123</td>
<td>12.2</td>
</tr>
<tr>
<td>L1 SP int</td>
<td>120</td>
<td>11.9</td>
</tr>
<tr>
<td>L1 SP adv</td>
<td>132</td>
<td>16.8</td>
</tr>
<tr>
<td>HS int</td>
<td>156</td>
<td>8.1</td>
</tr>
<tr>
<td>HS adv</td>
<td>155</td>
<td>13.2</td>
</tr>
<tr>
<td>L1 EN int</td>
<td>120</td>
<td>9.8</td>
</tr>
<tr>
<td>L1 EN adv</td>
<td>150</td>
<td>10.2</td>
</tr>
</tbody>
</table>

Table 6-21. Spanish /o/ duration means.

<table>
<thead>
<tr>
<th>Group</th>
<th>Duration (ms)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>121</td>
<td>11.9</td>
</tr>
<tr>
<td>L1 SP int</td>
<td>99</td>
<td>11.8</td>
</tr>
<tr>
<td>L1 SP adv</td>
<td>115</td>
<td>16.6</td>
</tr>
<tr>
<td>HS int</td>
<td>144</td>
<td>8.0</td>
</tr>
<tr>
<td>HS adv</td>
<td>134</td>
<td>12.9</td>
</tr>
<tr>
<td>L1 EN int</td>
<td>111</td>
<td>9.7</td>
</tr>
<tr>
<td>L1 EN adv</td>
<td>140</td>
<td>10.0</td>
</tr>
</tbody>
</table>

Table 6-22. Spanish overall duration means.

<table>
<thead>
<tr>
<th>Group</th>
<th>Duration (ms)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>121</td>
<td>9.0</td>
</tr>
<tr>
<td>L1 SP int</td>
<td>110</td>
<td>11.3</td>
</tr>
<tr>
<td>L1 SP adv</td>
<td>123</td>
<td>15.9</td>
</tr>
<tr>
<td>HS int</td>
<td>150</td>
<td>7.7</td>
</tr>
<tr>
<td>HS adv</td>
<td>144</td>
<td>12.4</td>
</tr>
<tr>
<td>L1 EN int</td>
<td>116</td>
<td>9.2</td>
</tr>
<tr>
<td>L1 EN adv</td>
<td>144</td>
<td>9.7</td>
</tr>
</tbody>
</table>

Table 6-23. Spanish /e/ IntDiff means.

<table>
<thead>
<tr>
<th>Group</th>
<th>IntDiff (dB)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>11.8</td>
<td>1.3</td>
</tr>
<tr>
<td>L1 SP int</td>
<td>11.3</td>
<td>1.5</td>
</tr>
<tr>
<td>L1 SP adv</td>
<td>8.4</td>
<td>2.2</td>
</tr>
<tr>
<td>HS int</td>
<td>8.5</td>
<td>1.0</td>
</tr>
<tr>
<td>HS adv</td>
<td>7.6</td>
<td>1.7</td>
</tr>
<tr>
<td>L1 EN int</td>
<td>10.7</td>
<td>1.3</td>
</tr>
<tr>
<td>L1 EN adv</td>
<td>9.5</td>
<td>1.3</td>
</tr>
</tbody>
</table>
Table 6-24. Spanish /o/ IntDiff means.

<table>
<thead>
<tr>
<th>Group</th>
<th>IntDiff (dB)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>12.9</td>
<td>1.3</td>
</tr>
<tr>
<td>L1 SP int</td>
<td>11.1</td>
<td>1.5</td>
</tr>
<tr>
<td>L1 SP adv</td>
<td>10.1</td>
<td>2.1</td>
</tr>
<tr>
<td>HS int</td>
<td>9.4</td>
<td>1.0</td>
</tr>
<tr>
<td>HS adv</td>
<td>8.7</td>
<td>1.7</td>
</tr>
<tr>
<td>L1 EN int</td>
<td>9.9</td>
<td>1.2</td>
</tr>
<tr>
<td>L1 EN adv</td>
<td>9.9</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Table 6-25. Overall Spanish IntDiff means.

<table>
<thead>
<tr>
<th>Group</th>
<th>IntDiff (dB)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>12.4</td>
<td>1.3</td>
</tr>
<tr>
<td>L1 SP int</td>
<td>11.2</td>
<td>1.5</td>
</tr>
<tr>
<td>L1 SP adv</td>
<td>9.3</td>
<td>2.1</td>
</tr>
<tr>
<td>HS int</td>
<td>8.9</td>
<td>1.0</td>
</tr>
<tr>
<td>HS adv</td>
<td>8.2</td>
<td>1.6</td>
</tr>
<tr>
<td>L1 EN int</td>
<td>10.3</td>
<td>1.2</td>
</tr>
<tr>
<td>L1 EN adv</td>
<td>9.7</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Table 6-26. Case study mean F1, F2, F2-F1, duration, and IntDiff values (pre-BP).

<table>
<thead>
<tr>
<th></th>
<th>F1 (Hz)</th>
<th>SD</th>
<th>F2 (Hz)</th>
<th>SD</th>
<th>F2-F1 (Hz)</th>
<th>SD</th>
<th>Dur (ms)</th>
<th>SD</th>
<th>IntDiff (dB)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>/e/</td>
<td>500</td>
<td>29.5</td>
<td>1775</td>
<td>254</td>
<td>1275</td>
<td>252.4</td>
<td>156</td>
<td>10.4</td>
<td>14.3</td>
<td>4.0</td>
</tr>
<tr>
<td>/o/</td>
<td>563</td>
<td>54.9</td>
<td>967</td>
<td>128.1</td>
<td>404</td>
<td>136.0</td>
<td>145</td>
<td>26.4</td>
<td>12.7</td>
<td>2.2</td>
</tr>
</tbody>
</table>

Table 6-27. Case study mean F1, F2, F2-F1, duration, and IntDiff values (post-BP).

<table>
<thead>
<tr>
<th></th>
<th>F1 (Hz)</th>
<th>SD</th>
<th>F2 (Hz)</th>
<th>SD</th>
<th>F2-F1 (Hz)</th>
<th>SD</th>
<th>Dur (ms)</th>
<th>SD</th>
<th>IntDiff (dB)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>/e/</td>
<td>447</td>
<td>41.6</td>
<td>1730</td>
<td>68.9</td>
<td>1283</td>
<td>92.2</td>
<td>166</td>
<td>51.9</td>
<td>9.7</td>
<td>2.4</td>
</tr>
<tr>
<td>/o/</td>
<td>449</td>
<td>41.6</td>
<td>1044</td>
<td>124.5</td>
<td>646</td>
<td>134.6</td>
<td>186</td>
<td>34.1</td>
<td>10.7</td>
<td>4.1</td>
</tr>
</tbody>
</table>

Table 6-28. Case study /e/ mean F1, F2, and F2-F1, duration, and IntDiff values pre- and post-BP.

<table>
<thead>
<tr>
<th></th>
<th>F1 (Hz)</th>
<th>SD</th>
<th>F2 (Hz)</th>
<th>SD</th>
<th>F2-F1 (Hz)</th>
<th>SD</th>
<th>Dur (ms)</th>
<th>SD</th>
<th>IntDiff (dB)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-BP</td>
<td>500</td>
<td>29.5</td>
<td>1775</td>
<td>254</td>
<td>1275</td>
<td>252.4</td>
<td>156</td>
<td>10.4</td>
<td>14.3</td>
<td>4.0</td>
</tr>
<tr>
<td>Post-BP</td>
<td>447</td>
<td>41.6</td>
<td>1730</td>
<td>68.9</td>
<td>1283</td>
<td>92.2</td>
<td>166</td>
<td>51.9</td>
<td>9.7</td>
<td>2.4</td>
</tr>
</tbody>
</table>
Table 6-29. Case study /o/ mean F1, F2, and F2-F1, duration, and IntDiff values pre- and post-BP.

<table>
<thead>
<tr>
<th></th>
<th>F1 (Hz)</th>
<th>SD</th>
<th>F2 (Hz)</th>
<th>SD</th>
<th>F2-F1 (Hz)</th>
<th>SD</th>
<th>Dur (ms)</th>
<th>SD</th>
<th>IntDiff (dB)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-BP</td>
<td>563</td>
<td>54.9</td>
<td>967</td>
<td>128.1</td>
<td>617</td>
<td>177.7</td>
<td>145</td>
<td>26.4</td>
<td>12.7</td>
<td>2.2</td>
</tr>
<tr>
<td>Post-BP</td>
<td>449</td>
<td>41.6</td>
<td>1044</td>
<td>124.5</td>
<td>646</td>
<td>134.6</td>
<td>186</td>
<td>34.1</td>
<td>10.7</td>
<td>4.1</td>
</tr>
</tbody>
</table>

Figure 6-2. BP control mean F1 and F2-F1 values (in Hz).
Figure 6-3. SP control mean F1 and F2-F1 values (in Hz).

Figure 6-4. BP and Spanish /e/ and /o/. 
Figure 6-5. Experimental and control BP F1 and F2-F1 values for /e/ and /o/.
Figure 6-6. Overall duration group means, by vowel type, where solid bars denote front /e/ and shaded bars denote back /o/.
Figure 6-7. Overall duration group means.
Figure 6-8. BP group means of IntDiff by vowel type, where solid bars denote front /e/ and shaded bars denote back /o/.

Figure 6-9. BP overall IntDiff group means.
Figure 6-10. F1 and F2-F1 (in Hz), BP control, case study (Draco), and the L1 English advanced BP group.

Figure 6-11. Spanish /e/ and /o/, experimental and control groups.
Figure 6-12. Overall duration group means by vowel type, where solid bars denote front /e/ and shaded bars denote back /o/.
Figure 6-13. Overall Spanish duration group means.
Figure 6.14. Group means of IntDiff by vowel type, where solid bars denote front /e/ and shaded bars denote back /o/.

<table>
<thead>
<tr>
<th>Group</th>
<th>SP cont</th>
<th>L1 SP int</th>
<th>L1 SP adv</th>
<th>HS int</th>
<th>HS adv</th>
<th>L1 EN int</th>
<th>L1 EN adv</th>
<th>L1 EN cs pre-BP</th>
<th>L1 EN cs post-BP</th>
</tr>
</thead>
<tbody>
<tr>
<td>front /e/</td>
<td>12.0</td>
<td>11.3</td>
<td>8.4</td>
<td>8.5</td>
<td>7.6</td>
<td>10.7</td>
<td>9.5</td>
<td>14.3</td>
<td>9.7</td>
</tr>
<tr>
<td>back /o/</td>
<td>13.2</td>
<td>11.1</td>
<td>10.1</td>
<td>9.4</td>
<td>8.7</td>
<td>9.9</td>
<td>9.7</td>
<td>12.7</td>
<td>10.7</td>
</tr>
</tbody>
</table>

Figure 6.15. Overall IntDiff group means.
Figure 6-16. Control vowels compared with Draco’s pre-BP Spanish vowels.

Figure 6-17. Control vowels compared with Draco’s post-BP Spanish vowels.
Figure 6-18. Case study pre- and post-BP Spanish formant values compared with Spanish and BP control values.
CHAPTER 7
DISCUSSION AND CONCLUSIONS

7.1 Overview

The goal of this dissertation has been to investigate the predictions of the Phonological Permeability Hypothesis (PPH) in an effort to determine what, if any, influence from a novel third language (L3) phonological system has on a native phonological system compared with a non-native phonological system. The PPH makes specific predictions as to the differences that should present between native and non-native speakers, namely that systems acquired in adulthood will evidence comparably more L3 influence than those acquired in childhood. If this prediction is not met, it would be necessary to modify the PPH and/or to give additional hypotheses due consideration. In this final chapter, I summarize the principal empirical findings of this study, comment on their implications for the PPH and for the cognitive organization of multilingual phonological systems, and remark on the limitations of this project and how they can be addressed in future research.

7.2 Summary of Major Findings

To test the PPH, a cross-sectional study of three types of English/Spanish bilinguals differing in age and context of acquisition (AoA) of Spanish was carried out to examine whether AoA determines relative vulnerability of the Spanish phonological system when exposed to a novel, typologically similar system (in this case, Brazilian Portuguese, BP). In addition, a longitudinal case study was conducted, observing an L1 English/L2 Spanish bilingual’s Spanish phonological perception and production prior to BP exposure, and his BP and Spanish 11 weeks later after an intensive six-week course followed by a six-week immersion program in Brazil. The focus of the investigation was the acquisition of reduced word-final unstressed vowels [ɪ] and [ʊ] in BP and potential regressive influence on Spanish fully-realized word-final unstressed...
[e] and [o]. Production, perception, and reaction time (RT) in Spanish and BP were examined through three different tasks, two of which are reported on in this dissertation. The cross-sectional results and case study data were compared with native speaker control data, and a direct comparison between the data from the case study’s two testing sessions was also made.

7.2.1 Perception

A timed forced-choice goodness task administered in BP and Spanish tested for preference of phonetically reduced [ɪ] and [ʊ] or fully realized [e] and [o] in word-final position in disyllabic CV.CV nonce words with penultimate stress. There were no significant differences in accuracy rate or reaction time (RT) when comparing the BP cross-sectional data with the BP control group, evidence of a clear preference for reduced vowels in BP regardless of stage of development (intermediate or advanced proficiency), age of acquisition of Spanish, or whether testing was carried out in an immersion context. Considering the limited BP exposure of the intermediate learners, the data suggest the possibility that word-final vowel reduction is very salient and robust in the input, in turn driving rapid reranking of constraints in L3 BP. It is of note that the case study participant’s accuracy score was at ceiling and thus in line with the cross-sectional data, although his RTs were slower, suggesting the possibility of accuracy at a cost to processing.

Spanish accuracy and RT cross-sectional and case study data also reveal a lack of statistically significant differences among the control and experimental groups, indicating that in terms of a preference for fully realized mid vowels [e o] versus phonetically reduced [ɪ ʊ] in word-final unstressed syllables, both L1 and L2 Spanish speakers maintain a native-like preference for mid vowels throughout the course of L3 BP acquisition. RTs were also stable across groups, indicating that decision-making speed was not affected by L3 influence.
### 7.2.2 Production

A delayed repetition task tested for production of word-final unstressed /e/ and /o/ inputs in Spanish and BP, and production data were measured acoustically for F1, F2, F2-F1, voicing duration, and relative intensity (intDiff). A comparison of the BP and Spanish data revealed no statistically significant difference between Spanish control and BP control duration and intDiff, and thus focus was primarily on F1, F2, and F2-F1 values. BP data indicated that the L1 English and L1 Spanish learners (intermediate and advanced) had successfully converged on the BP target. The early Spanish/English bilinguals evidenced target BP [ʊ] and a hybrid front vowel consisting of target-like F1 frequencies, but target-deviant F2 frequencies and F2-F1 frequency ranges. The case study participant also produced hybrid segments, but evidenced partial convergence on the BP target in terms of F1 for /e/ and /o/ and F2 for /o/.

While none of the Spanish experimental production data differed significantly from the Spanish control data in terms of height, backness, duration, or intensity, the case study data told a different story. Although the participant’s pre-BP Spanish is in line with the control data with the exception of the F2 value for /e/, his post-BP Spanish session yielded significantly lower F1 values that are outside of the Spanish control range, indicating his front vowels had raised over 11 weeks and were higher than the Spanish controls’. His /o/ had also moved farther back in the vowel space, closer toward BP [ʊ] and significantly more back than Spanish [o].

In summary, while the cross-sectional study participants largely converged on the L3 BP target in terms of perception and production, there was no evidence of BP influence on their Spanish perception or RT, and none of the groups produced segments that deviated from the Spanish control norm. However, while the case study data align with the cross-sectional data in terms of perception and RT, Draco produced vowel segments during his second Spanish testing
session that were considerably more BP-like and his overall accent was rated as significantly less native-like.

7.2.3  Additional Considerations of BP Influence on L1 and L2 Spanish Production

Considering Draco’s production data, it is conceivable that BP influence has indeed affected the cross-sectional participants’ speech production, and it is perhaps even possible that L1 Spanish systems were affected differently than L2 Spanish systems, but that the results of such influence still fell within the range of the Spanish control data. If this were the case, the data would obscure such L3 BP influence. The reality of this possibility is supported by the case study data; although Draco’s proficiency score and foreign accent rating qualified him as a near-native speaker of Spanish at the onset of BP acquisition, acoustic scrutiny of his vowel quality revealed that one of the parameters measured in his pre-BP testing session fell well below the Spanish norm. Even a large increase in the value of this parameter over the course of the investigation would have placed his production within the range of the Spanish controls, and without the pre-BP Spanish data there would be no way of knowing that a significant change had occurred.

It is also plausible that the BP learners’ Spanish was affected, but that influence was temporary and had subsided by the time of testing (see Ecke & Hall, 2012, for evidence of rapid recovery from L2/L3 influence). Recall that Draco was tested after only 11 weeks of BP exposure and temporally speaking, had considerably less exposure to BP than his peers. Such temporary effects would further support the suggestion that BP influence is limited to processing and does not affect mental representation.

The likelihood of BP influence on L1 systems is strengthened by recent research. In a study of L1 English learners of L2 Korean, Chang (2012) presents acoustic evidence of changes to English stop production attributed to Korean influence over the course of a six week study.
abroad program in South Korea. Levy, McVeigh, Marful, and Anderson (2007) also report L2 influence on the L1 early on in L2 acquisition, which they claim is due to inhibition of the L1 phonology during L2 use, in turn causing retrieval problems during L1 use. Thus, it is plausible that similar results could be found for L1 Spanish learners that were found for Draco, although this is an empirical question that will be addressed moving forward. The discussion continues with considerations of the theoretical implications of the results of this study.

7.3 Theoretical Implications

Having reviewed the empirical findings of the study, I now return to the research questions presented in Chapter 1. Each question will be addressed with respect to the results of this dissertation, followed by a consideration of broader implications for the study of multilingualism.

1. Is the phonological system of a non-primary language acquired after a so-called critical/sensitive period significantly more vulnerable to instability than that of a primary language?

Recall that the PPH predicts that L3 BP influence will be more pervasive and surface more rapidly in non-native Spanish phonological systems than in native phonological systems. Considering the major findings, this prediction was not met. None of the L3 BP learner groups’ Spanish perception, production, or RT data deviated from the Spanish control norm, indicating that all three types of bilinguals performed within the range of the L1 Spanish/L2 English controls. Therefore, there is no empirical support for a maturationally-conditioned critical period for stability at the level of mental representation or processing during speech perception and production. Instead, the data suggest that, at least in controlled experiments, these learners demonstrate equal resistance to BP phonological influence independent of Spanish age of acquisition (AoA) and BP proficiency.
Similarly to the cross-sectional data, data from the L2 Spanish longitudinal case study do not reflect BP influence as it relates to speech perception and the processing of phonetic and phonological information as measured by RT. However, Draco’s vowel quality became more BP-like over the course of 11 weeks of intensive exposure. Therefore, even though he had not fully converged on the L3 BP constraint ranking, his L3 grammar influenced his Spanish production. Such perception/production asymmetry suggests that the observed changes are due to competition of the Spanish and BP phonological grammars during speech production, and that the rapid onset of BP influence could be a result of increased processing demands during speech production, but not due to system competition during speech perception or modifications to the mental representation. Thus, these data indicate that L3 influence on a native-like system of a structurally similar language is possible after a very short period of time (and possibly in terms of failure to suppress the novel system during speech production). The asymmetry of Draco’s perception and production results leads to the question of whether longitudinal investigation of L1 Spanish/L2 English speakers and heritage speaker bilinguals will yield similar results, and leaves the door open to two possibilities. The first is that L1 and L2 Spanish speakers are equally (in)vulnerable to BP influence on speech production, evidence of which would falsify the PPH. The second is that L1 Spanish speakers evidence more resistance to BP influence during speech production than L2 Spanish speakers, evidence of which would support the PPH. As seen in this discussion, while this research question cannot be answered definitively at this time, it has served an essential function as an exploratory question, the examination of which has narrowed its focus for further study.

As shown in the above discussion, treating the data fairly and indexically as they were presented, the interim conclusion was made that there is a lack of support for the strong version
of the PPH. However, this conclusion stems from a limited data set, examining a single phonological phenomenon. It is possible that the salient acoustic quality of word-final reduced vowels might have allowed learners to reliably distinguish between target and non-target outputs in the perception task at a phonetic or auditory, as opposed to phonological, level (see, e.g., Best, Roberts, & Sithole, 1988). Examination of additional phenomena that are relatively less salient in the input could help clarify whether the learners’ Spanish accuracy observed in this study does in fact reflect a stable mental representation. Similar patterns in the data across phenomena, regardless of salience, would support the findings in this study and favor the hypothesis that L1 and L2 Spanish speakers’ mental representations are equally resistant to L3 BP influence. Additional data have been collected that examine postvocalic underlying voiced stops in Spanish and BP, which surface as continuants in Spanish and as stops in BP. It is possible that acoustic and auditory differences between postvocalic stops and continuants are not as salient as word-final reduced vowels and that examination of the stop/continuant alternation will better tap phonological representation. Significant differences in perceptual accuracy between the controls and learners and/or between the L1 and L2 Spanish speakers could lend support for the strong version of the PPH.

2. What do any possible differences of L3 influence delimited by age of acquisition tell us about the nature of a phonological system acquired before vs. after a critical period?

As reviewed in the discussion of the first research question, the differences between the cross-sectional and case study data leave open more than one possible answer and therefore this question cannot fully be pursued without additional longitudinal data. However, regardless of which of the two outcomes noted above is realized, there is a strong possibility of a perception/production asymmetry across learner groups that could indicate that any observed instability in production, differential according to AoA or not, is indicative of a competition of
grammars during speech production. As such, the nature of L3 influence on L1 and/or L2 processing will be of special interest, and warrants a discussion of bi/multilingual processing.

Evidence from bilingual processing research indicates simultaneous activation of a bilingual’s grammars (see e.g., Colomé, 2001, for phonological evidence), and imaging studies point to shared cortical activation (see Abutalebi, 2008, for a review). Extra-linguistic cognitive functions are therefore necessary to focus attention on Spanish and to filter interference from BP, and crucially to select among competing constraint rankings as stated by the Constraint Fluctuation Hypothesis (Goodin-Mayeda et al., 2011). Results from bi/multilingual processing investigations and neuroimaging studies have been interpreted as evidence that interference is mediated via inhibition of the non-target languages (e.g. Abutalebi, 2008; Abutalebi & Green, 2007). The results presented in this dissertation provide tentative support for the proposal that L2 learners’ inhibitory control processes are not significantly affected for perception when a typologically-similar L3 is acquired, and native speakers do not appear to exhibit superior inhibitory control when compared to L2 speakers of the same language. However, such a suggestion must be put to empirical scrutiny, which will require independent measures of extra-linguistic factors (i.e., executive control functions). This point will be addressed further in Section 7.4, following a discussion of the implications of the results reviewed here for the study of non-native phonology and acquisition more generally.

As presented in Chapter 1, this study was designed to answer questions regarding the mental representation of a phonological system acquired before versus after a critical period, an ongoing debate due in large part to the challenge of teasing apart domain-general learning from domain-specific learning. In addition to the contribution the present study has made in honing

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1 But see e.g., Costa, Albareda, and Santesteban (2008) and Costa, La Heif, and Navarrete (2006) for an account of enhanced activation, as opposed to inhibition.
the focus of these questions of differential stability for future study, the results of this investigation of L3 influence on L1 and L2 systems have important implications for the nature and cognitive organization of multiple phonological grammars. At the outset of this project, a proposal was made based on work by Abrahamsson and Hyltenstam (2009) that changes to mental representations acquired via domain-specific mechanisms might be observable via a combination of perception evidence and acoustic scrutiny. The original scope of this dissertation did not extend to questions of phonological processing and functions of general cognition, or consider the possible outcome of an asymmetry in perception and production. However, the case study data have highlighted the dynamic nature of multilingual phonological systems and necessitated a revised assessment of the research questions and possible outcomes. While a definitive answer regarding the nature of pre- and post-critical period phonological systems can follow only from further investigation of L3 influence, an asymmetry in perception and production has the potential to provide the evidence necessary to disentangle domain-general and domain-specific phonological learning, one of the primary goals of generative phonological acquisition research.

7.4 Limitations and Future Research

The PPH was originally designed to be tested via longitudinal investigation. Without measures taken at the onset of L3 acquisition, the widely-acknowledged variation characteristic of bilinguals (early and late alike) makes it impossible to glean with any certainty what the Spanish phonological system of each intermediate or advanced BP speaker that was tested looked like at the onset of L3 BP acquisition. Thus, a cross-sectional investigation of L3 acquisition and its effects on native and non-native phonological systems, while logistically more practical, impedes the ability to know what the possibly modified language looked like at the onset of L3 acquisition. To control for variation, it is therefore maximally beneficial to measure
learners’ baseline phonological perception, production, and processing and to follow their acquisition over time. In this way, each learner acts as his/her own control, rather than comparing static learner performance with a control sample that also exhibits variation. This is especially important in the investigation of L3 regressive influence, so that it can be known whether any data that depart from the control norm is in fact a result of L3 influence and not due to learner variation.

In addition to a baseline measurement of the learners’ Spanish, examination of the learners’ L3 system at the initial stages will be imperative moving forward. A considerable body of L3 initial stages syntax research points to transfer of the Spanish system during the initial stages of L3 BP acquisition by English/Spanish bilinguals, independent of whether a learner’s Spanish system was acquired early or later in life (e.g. Cabrelli Amaro, in press; Giancaspro, Halloran, & Iverson, in press; Rothman, 2010). This evidence led to the assumption in the present study that the participants’ Spanish phonological grammar (in this case, set of constraint rankings) was copied during the initial stages of L3 BP. A measurement of the learners’ BP at the very initial stages of acquisition would further support this syntactic evidence and extend the domains across which it applies, but it could also potentially yield evidence of initial stages transfer from the English phonology or the emergence of the unmarked (TETU). Regardless of the outcome, testing at the L3 initial stages provides an unequaled opportunity to observe the path of L3 acquisition that cross-sectional investigation simply does not afford. The use of cross-sectional methodology is therefore the most marked limitation of this study. Had baseline data been available from the full sample tested here, stronger claims regarding the tenability of the PPH could be made.
While logistics did not permit a longitudinal study of the full sample in this project, a longitudinal case study was carried out, and the results of the study partially contradict the cross-sectional data. Data from a sample size of one limits us in terms of generalizing findings and making probabilistic statements about L3 acquisition and its regressive effects on speech production and processing in an existing system. That being said, Draco’s performance strongly suggests that L3 BP influence on Spanish phonological processing is in fact possible, at least when the Spanish system is acquired in adulthood. While large numbers of learners with similar profiles are a challenge to assemble for statistically-significant longitudinal investigations because of the small window of time during which baseline testing can be performed, data from a significant sample size will substantiate (or not) the tentative conclusions made based on the case study results. Most importantly, longitudinal data comparing learners like Draco with native speakers of Spanish will provide further insight into the plausibility of the PPH. Given the case study data, likely indicative of BP influence stemming from failure to suppress the L3 system during L2 production, future testing will incorporate online methodologies such as event related potentials (ERP) studies to explore the role of information processing. Independently, correlational extra-linguistic measures of executive functions will also be necessary to verify the role of inhibitory control in L3 influence. Finally, expansion of the variety of tasks implemented will also increase understanding of whether the degree of L3 influence on native and non-native systems is modulated by task demands (see Gutierrez, Pilotti, Romero, Mahamane, & Broderick, 2012, for a discussion).

One of the intentions of this dissertation has been to initiate a novel strand of research in the hopes of informing ongoing debates of non-native language acquisition and contributing to the understanding of the cognitive organization of multilingual systems. Moving forward, testing
of the PPH will be extended to address questions of mental representation and processing that intersect domains and language pairings. Data were collected from the cross-sectional sample and case study participant that examine two syntactic phenomena that present differently in Spanish and BP, subject-to-subject raising across experiencers and differential object marking, and examination of L1 and L2 Spanish (in)vulnerability at the level of narrow syntax and at the syntax-semantics interface could provide insight into cross-linguistic influence across linguistic domains. Recent investigations into L3 syntactic influence on an L2 by Bronson (2010) and Aysan (2012) have yielded evidence of regressive transfer effects with respect to the formulation of subject-extracted and object-extracted relative clauses and the use of overt vs. null pronouns, respectively. It remains to be seen, however, whether comparable influence will be found in L1 systems. It will also be important to test the predictions of the PPH via examination of languages that are not as closely related as Spanish and BP. A small but promising body of recent L3 research investigates progressive transfer at the initial stages of L3 acquisition, and finds that structural similarity drives the mechanism that transfers one linguistic system over the other to the L3, even when the languages in question are not mutually intelligible like Spanish and BP (e.g., Tuvan/Russian/English, Kulundary & Gabriele, 2012; Uzbek/Russian/Turkish, Özçelik, 2013; Polish/French/English, Wrembel, 2012). It is thus conceivable that the same could hold true for regressive transfer, and it will be necessary to submit similar language triads to examination to determine the role of structural similarity in L3 influence.

A primary goal of the study of cross-linguistic influence is to understand its dynamic nature across the lifespan, and long-term longitudinal testing of the PPH will contribute to the understanding of bidirectional influence over time and in a variety of contexts. Of particular interest will be the questions of whether any observed differential influence is temporary or can
have lasting effects, what role (if any) context and language status (L1 versus L2) play, and whether there are significant differences between early (in this case, heritage speaker) bilinguals and adult L2 learners. For example, what kind of processing routines are developed in cases of sustained immersion, and what does that mean for influence on the L1 and/or L2? Are L3 effects on an existing native and/or non-native system temporary, as indicated by Draco’s anecdotal evidence? How do prolonged L3 immersion and an increase in proficiency contribute to enhancement of executive control (e.g., Cedden & Simsek, 2012; Poarch & van Hell, 2013), and are outcomes for the affected system conditioned by language status? Recent L1 attrition research (e.g. De Leeuw et al., 2012; Ecke & Hall, 2012) submits evidence of L1 instability and questions the permanence of L2 influence. Ecke and Hall indicate a rapid recovery of stability despite infrequent L1 use (e.g. Ecke & Hall, 2012), pointing to processing issues as a source of L1 modification. Future research will help determine what, if any, differences there are between native and non-native systems in terms of recovery, and whether Ecke and Hall’s findings might extend to phonology.

Finally, it will also be useful to compile samples that have (significant) equal numbers across groups in immersion and non-immersion contexts to better determine what role immersion might play in degree of L3 influence. While immersion was not found to be a significant predictor of BP influence in the present study, the levels of the variable were not divided equally within the majority of the experimental groups, despite equal numbers overall of learners tested in each of the two contexts.

7.5 Summary

The cross-sectional evidence presented in this study does not indicate that phonological systems acquired in adulthood are more vulnerable to influence from a typologically similar L3 than systems acquired in early childhood at the levels of mental representation or processing.
Results from the cross-sectional study did not reveal any between-group differences in perception, production, or RT in terms of influence from BP word-final reduced vowels on Spanish fully-realized vowels. Therefore, these data sets appear to align with the possibility that age of acquisition does not determine the relative stability of a phonological system in terms of mental representation or processing. However, while these data do not support the PPH, evidence meeting the criteria for falsification of the PPH is also lacking. Results of a longitudinal case study of an L1 English/L2 Spanish/L3 BP speaker are indicative of rapid and permeating (and perhaps short-lived) L3 influence on the learner’s Spanish processing during speech production. The complete data set needed to support or falsify the PPH will consist of results from measures of production, perception, online processing, and independent measures of extra-linguistic executive functions. A large-scale longitudinal investigation of the three bilingual types tested here will reveal whether early and late acquirers of Spanish are equally vulnerable to L3 influence and what the nature of any observed vulnerability is.

As is the case with most scientific investigations, the outcome of this project has raised more questions than it has provided answers. Having established that the examination of L3 acquisition provides a novel source to test the claims and predictions of SLA theories and models, these questions that have surfaced throughout this dissertation will serve as a foundation for a novel research program that will contribute to the emerging field of formal approaches to L3 acquisition and non-native phonological acquisition more generally.
Identification

Please enter the 4-digit identification code that you were given in the email sent to you. You will be asked to supply this code for each part of the research project you participate in.*

1) Age*

2) Sex*
[ ] Male
[ ] Female

3) city/country of birth*

4) Are you a student?*
[ ] Yes
[ ] No

5) If you answered 'yes', indicate your current level of study. (For example, undergrad - junior year; graduate school - first year).

6) If you answered 'no', what is your current profession?

7) What is/are your native language(s)?*

1: _________________________
2: _________________________
3: _________________________

8) What language(s) does your mother speak? If more than one, please explain.

__________________________________________
9) What language(s) does your father speak? If more than one, please explain.
____________________________________________

10) If you were born outside of the US, how old were you when you arrived?
____________________________________________

11) How old were you when you began to learn:*  
   English?: _________________________  
   Spanish?: _________________________  
   Portuguese?: _________________________

12) Please indicate the countries where you lived during your schooling (k-12, undergrad, grad school), and the language(s) of instruction.
   1: _________________________  
   2: _________________________  
   3: _________________________  
   4: _________________________  
   5: _________________________

13) What other languages were used in your education?*  
____________________________________________

On the following pages, please tell me some more about your use of English, Spanish, and Portuguese.

Portuguese

14) Per week, how much time do you spend speaking Portuguese?*  
   [ ] I speak Portuguese every day.  
   [ ] I speak Portuguese several times a week.  
   [ ] I speak Portuguese at least once a week.  
   [ ] I speak Portuguese at least once a month.  
   [ ] I speak Portuguese a few times a year.
15) With whom do you usually speak Portuguese?*
[ ] spouse or partner
[ ] friends that are native speakers of Portuguese
[ ] friends that are not native speakers of Portuguese
[ ] boss or work colleagues
[ ] other people

16) If you answered "other people" on the previous question, please explain.
____________________________________________

17) How many of your friends speak Portuguese?*
[ ] all of my friends
[ ] the majority of my friends
[ ] half of my friends
[ ] a few of my friends
[ ] none of my friends

18) Which of the following activities do you take part in each week?*
[ ] reading newspapers/magazines written in Portuguese
[ ] reading books written in Portuguese
[ ] watching TV in Portuguese
[ ] watching movies in Portuguese
[ ] listening to music in Portuguese
[ ] none

19) Which of the following activities do you take part in at least once a month?*
[ ] reading newspapers/magazines written in Portuguese
[ ] reading books written in Portuguese
[ ] watching TV in Portuguese
[ ] watching movies in Portuguese
[ ] listening to music in Portuguese
[ ] none
20) How would you evaluate your comprehension of Portuguese?*
[ ] very good
[ ] pretty good
[ ] OK
[ ] not so great
[ ] really bad

21) How would you evaluate your speaking ability in Portuguese?*
[ ] very good
[ ] pretty good
[ ] OK
[ ] not so great
[ ] really bad

22) How would you evaluate your reading ability in Portuguese?*
[ ] very good
[ ] pretty good
[ ] OK
[ ] not so great
[ ] really bad

23) How would you evaluate your writing ability in Portuguese?
[ ] very good
[ ] pretty good
[ ] OK
[ ] not so great
[ ] really bad

24) Talking on the phone to someone you don't know, could you pass for a monolingual native speaker of Portuguese?*
[ ] always
[ ] most of the time
[ ] sometimes
[ ] almost never
[ ] never
25) In what situations do you normally use Portuguese most frequently?*
____________________________________________

26) Is it very important for you to maintain your Portuguese? Please explain.*
____________________________________________

____________________________________________

Spanish

27) Per week, how much time do you spend speaking Spanish?*
[ ] I speak Spanish every day.
[ ] I speak Spanish several times a week.
[ ] I speak Spanish at least once a week.
[ ] I speak Spanish at least once a month.
[ ] I speak Spanish a few times a year.

28) With whom do you usually speak Spanish?*
[ ] spouse or partner
[ ] friends that are native speakers of Spanish
[ ] friends that are not native speakers of Spanish
[ ] boss or work colleagues
[ ] other people

29) If you answered "other people" on the previous question, please explain:
____________________________________________

30) How many of your friends speak Spanish?*
[ ] all of my friends
[ ] the majority of my friends
[ ] half of my friends
[ ] a few of my friends
[ ] none of my friends
31) Which of the following activities do you take part in each week?*
[ ] reading newspapers/magazines written in Spanish
[ ] reading books written in Spanish
[ ] watching TV in Spanish
[ ] watching movies in Spanish
[ ] listening to music in Spanish
[ ] none

32) Which of the following activities do you take part in at least once a month?*
[ ] reading newspapers/magazines written in Spanish
[ ] reading books written in Spanish
[ ] watching TV in Spanish
[ ] watching movies in Spanish
[ ] listening to music in Spanish
[ ] none

33) How would you evaluate your comprehension of Spanish?*
[ ] very good
[ ] pretty good
[ ] OK
[ ] not so great
[ ] really bad

34) How would you evaluate your speaking ability in Spanish?*
[ ] really good
[ ] pretty good
[ ] OK
[ ] not so great
[ ] really bad

35) How would you evaluate your reading ability in Spanish?*
[ ] really good
[ ] pretty good
[ ] OK
[ ] not so great
[ ] really bad
36) How would you evaluate your writing ability in Spanish?*
[ ] really good
[ ] pretty good
[ ] OK
[ ] not so great
[ ] really bad

37) Talking on the phone to someone you don't know, could you pass for a monolingual native speaker of Spanish?*
[ ] always
[ ] most of the time
[ ] sometimes
[ ] almost never
[ ] never

38) In what situations do you normally use Spanish most frequently?*

____________________________________________

39) Is it very important for you to maintain your Spanish? Please explain.*

____________________________________________

English

40) Per week, how much time do you spend speaking English?*
[ ] I speak English every day.
[ ] I speak English several times a week.
[ ] I speak English at least once a week.
[ ] I speak English at least once a month.
[ ] I speak English a few times a year.
41) With whom do you usually speak English?*
[ ] spouse or partner
[ ] friends that are native speakers of English
[ ] friends that are not native speakers of English
[ ] boss or work colleagues
[ ] other people

42) If you answered "other people" on the previous question, please explain:
____________________________________________

43) How many of your friends speak English?*
[ ] all of my friends
[ ] the majority of my friends
[ ] half of my friends
[ ] a few of my friends
[ ] none of my friends

44) Which of the following activities do you take part in each week?*
[ ] reading newspapers/magazines written in English
[ ] reading books written in English
[ ] watching TV in English
[ ] watching movies in English
[ ] listening to music in English
[ ] none

45) Which of the following activities do you take part in at least once a month?*
[ ] reading newspapers/magazines written in English
[ ] reading books written in English
[ ] watching TV in English
[ ] watching movies in English
[ ] listening to music in English
[ ] none
46) How would you evaluate your comprehension of English?*
[ ] very good
[ ] pretty good
[ ] OK
[ ] not so great
[ ] really bad

47) How would you evaluate your speaking ability in English?*
[ ] really good
[ ] pretty good
[ ] OK
[ ] not so great
[ ] really bad

48) How would you evaluate your reading ability in English?*
[ ] very good
[ ] pretty good
[ ] OK
[ ] not so great
[ ] really bad

49) How would you evaluate your writing ability in English?*
[ ] very good
[ ] pretty good
[ ] OK
[ ] not so great
[ ] really bad

50) Talking on the phone to someone you don't know, could you pass for a monolingual
native speaker of English?*
[ ] always
[ ] most of the time
[ ] sometimes
[ ] almost never
[ ] never

51) In what situations do you normally use English most frequently?*

__________________________________________

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52) Is it very important for you to maintain your English? Please explain.*
____________________________________________

Additional Questions

53) For communicative purposes, which language(s) are you most comfortable speaking? Please explain.

54) Do you know any additional languages?*
[ ] Yes
[ ] No

55) If you answered yes, which language(s)?
1: _________________________
2: _________________________
3: _________________________
4: _________________________

56) Please evaluate your proficiency in the language(s) you have mentioned above: I speak fluently; I speak pretty well; I've studied it, but I don't speak very well; I speak very little.
____________________________________________
APPENDIX B
SPANISH PROFICIENCY MEASUREMENT

Instructions: Each of the following sentences contains a blank space ______ indicating that a word or phrase has been omitted. From the four choices select the one which, when inserted in the space ________, best fits in with the meaning of the sentence as a whole.

1) Al oír del accidente de su buen amigo, Paco se puso __________ .
   [ ] alegre
   [ ] fatigado
   [ ] hambriento
   [ ] desconsolado

2) No puedo comprarlo porque me __________ dinero.
   [ ] falta
   [ ] dan
   [ ] presta
   [ ] regalan

3) Tuvo que guardar cama por estar _______.
   [ ] enfermo
   [ ] vestido
   [ ] ocupado
   [ ] parado

4) Aquí está tu café, Juanito. No te quemes, que está muy _____ .
   [ ] dulce
   [ ] amargo
   [ ] agrio
   [ ] caliente

5) Al romper los anteojos, Juan se asustó porque no podía _____ sin ellos.
   [ ] discurrir
   [ ] oír
   [ ] ver
   [ ] entender

6) ¡Pobrecita! Está resfriada y no puede _____ .
   [ ] salir de casa
   [ ] recibir cartas
   [ ] respirar con pena
1) leer las noticias

7) Era una noche oscura sin _____.
   [ ] estrellas
   [ ] camas
   [ ] lágrimas
   [ ] nubes

8) Cuando don Carlos salió de su casa, saludó a un amigo suyo: -Buenos días, _____.
   [ ] ¿Qué va?
   [ ] ¿Cómo es?
   [ ] ¿Quién es?
   [ ] ¿Qué tal?

9) ¡Qué ruido había con los gritos de los niños y el _____ de los perros!
   [ ] olor
   [ ] sueño
   [ ] hambre
   [ ] ladrar

10) Para saber la hora, don Juan miró el _____.
    [ ] calendario
    [ ] bolsillo
    [ ] estante
    [ ] despertador

11) Yo, que comprendo poco de mecánica, sé que el auto no puede funcionar sin _____.
    [ ] permiso
    [ ] comer
    [ ] aceite
    [ ] bocina

12) Nos dijo mamá que era hora de comer y por eso _____
    [ ] fuimos a nadar
    [ ] tomamos asiento
    [ ] comenzamos a fumar
    [ ] nos acostamos pronto
13) ¡Cuidado con ese cuchillo o vas a _____ el dedo!
[ ] cortarte
[ ] torcerte
[ ] comerte
[ ] quemarte

14) Tuvo tanto miedo de caerse que se negó a _____ con nosotros.
[ ] almorzar
[ ] charlar
[ ] cantar
[ ] patinar

15) Abrió la ventana y miró: en efecto, grandes lenguas de _____ salían llameando de las casas.
[ ] zorros
[ ] serpientes
[ ] cuero
[ ] fuego

16) Compró ejemplares de todos los diarios pero en vano. No halló _____ .
[ ] los diez centavos
[ ] el periódico perdido
[ ] la noticia que deseaba
[ ] los ejemplos

17) Por varias semanas acudieron colegas del difunto profesor a _____ el dolor de la viuda.
[ ] aliviar
[ ] dulcificar
[ ] embromar
[ ] estorbar

18) Sus amigos pudieron haberlo salvado pero lo dejaron _____ .
[ ] ganar
[ ] parecer
[ ] perecer
[ ] acabar
19) Al salir de la misa me sentía tan caritativo que no pude menos que _____ a un pobre mendigo que había allí sentando.
[ ] pegarle
[ ] darle una limosna
[ ] echar una mirada
[ ] maldecir

20) Al lado de la Plaza de Armas había dos limosneros pidiendo _____.
[ ] pedazos
[ ] paz
[ ] monedas
[ ] escopetas

21) Siempre maltratado por los niños, el perro no podía acostumbrarse a _____ de sus nuevos amos.
[ ] las caricias
[ ] los engaños
[ ] las locuras
[ ] los golpes

22) ¿Dónde estará mi cartera? La dejé aquí mismo hace poco y parece que el necio de mi hermano ha vuelto a _____.
[ ] dejármela
[ ] deshacérmela
[ ] escondérmela
[ ] acabármela

23) Permaneció un gran rato abstraído, los ojos clavados en el fogón y el pensamiento _____.
[ ] en el bolsillo
[ ] en el fuego
[ ] lleno de alboroto
[ ] Dios sabe dónde

24) En vez de dirigir el tráfico estabas charlando, así que tú mismo _____ del choque.
[ ] sabes la gravedad
[ ] eres testigo
[ ] tuviste la culpa
[ ] conociste a las víctimas
25) Posee esta tierra un clima tan propio para la agricultura como para _____ .
[ ] la construcción de trampas
[ ] el fomento de motines
[ ] el costo de vida
[ ] la cría de reses

26) Aficionado leal de obras teatrales, Juan se entristeció al saber _____ del gran actor.
[ ] del fallecimiento
[ ] del éxito
[ ] de la buena suerte
[ ] de la alabanza

27) Se reunieron a menudo para efectuar un tratado pero no pudieron _____ .
[ ] desavenirse
[ ] echarlo a un lado
[ ] rechazarlo
[ ] llevarlo a cabo

28) Se negaron a embarcarse porque tenían miedo de_____.
[ ] los peces
[ ] los naufragios
[ ] los faros
[ ] las playas

29) La mujer no aprobó el cambio de domicilio pues no le gustaba _____ .
[ ] el callejero
[ ] el puente
[ ] esa estación
[ ] aquel barrio

30) Era el único que tenía algo que comer pero se negó a _____ .
[ ] hojearlo
[ ] ponérselo
[ ] conservarlo
[ ] repartirlo
El sueño de Juan Miró

Hoy se inaugura en Palma de Mallorca la Fundación Pilar y Joan Miró, en el mismo lugar en donde el artista vivió sus últimos treinta y cinco años. El sueño de Joan Miró se ha cumplido (1). Los fondos donados a la ciudad por el pintor y su esposa en 1981 permitieron que el sueño se completó (2); más tarde, en 1986, el Ayuntamiento de Palma de Mallorca decidió completado (3) al arquitecto Rafael Moneo un edificio que terminado (4) a la vez como sede de la entidad y como museo moderno. El proyecto ha tenido que enfrentado (5) múltiples obstáculos de carácter administrativo. Miró, coincidiendo cumplido (6) los deseos de toda su familia, quiso que su obra no quedara expuesta en ampollosos panteones de arte o en acudalado (7) de coleccionistas acudalados; por ello, en 1981, creó la fundación mallorquina. Y cuando estaba cumplido (8) punto de morir, donó terrenos y edificios, así como las obras de arte que en ellos terminado (9).

El edificio que ha construido Rafael Moneo se enmarca en denominada "Territorio Miró", espacio en el que se han situado (11) de situar los distintos edificios que constituyen la herencia del pintor.

El acceso a los mismos quedará liberado (12) para evitar el deterioro de las obras. Por otra parte, se admitido (13), en los talleres de grabado y litografía, cursos de las distintas técnicas de estampación. Estos talleres también se cederán periódicamente a distintos artistas contemporáneos, buscado (15) se busca que el "Territorio Miró" sea (16) un centro vivo de creación y difusión del arte a todos los (17).

La entrada costará 500 pesetas y las previsiones dadas a conocer ayer aspiran cumplido (18) que el centro acoja a unos 150.000 visitantes al año. Los responsables esperan que la institución funcione a cumplido (19) rendimiento a principios de la cumplido (20) semana, si bien el catálogo completo de las obras de la Fundación Pilar y Joan Miró no estará listo hasta dentro de dos años.

Hoy se inaugura en Palma de Mallorca la Fundación Pilar y Joan Miró, en el mismo lugar en donde el artista vivió sus últimos treinta y cinco años. El sueño de Joan Miró se ha cumplido (1).
[ ] cumplido
[ ] completado
[ ] terminado
Los fondos donados a la ciudad por el pintor y su esposa en 1981 permitieron que el sueño se ________ (2);
[ ] inició
[ ] iniciara
[ ] iniciaba

más tarde, en 1986, el Ayuntamiento de Palma de Mallorca decidió ________ (3)
[ ] encargar
[ ] pedir
[ ] mandar

al arquitecto Rafael Moneo un edificio que ________ (4) a la vez como sede de la entidad y como museo moderno.
[ ] hubiera servido
[ ] haya servido
[ ] sirviera

El proyecto ha tenido que ________ (5) múltiples obstáculos de carácter administrativo.
[ ] superar
[ ] enfrentarse
[ ] acabar

Miró, coincidiendo ________ (6) los deseos de toda su familia,
[ ] por
[ ] en
[ ] con

quiso que su obra no quedara expuesta en ampulosos panteones de arte o en ________ (7) de coleccionistas acaudalados; por ello, en 1981, creó la fundación mallorquina.
[ ] voluntad
[ ] poder
[ ] favor

Y cuando estaba ________ (8) punto de morir,
[ ] al
[ ] en
[ ] a
donó terrenos y edificios, así como las obras de arte que en ellos ________ (9).
[ ] había
[ ] había
[ ] hubo

El edificio que ha construido Rafael Moneo se enmarca en _________ (10) se denomina "Territorio Miró",
[ ] que
[ ] el que
[ ] lo que

espacio en el que se han ________ (11) de situar los distintos edificios que constituyen la herencia del pintor.
[ ] pretendido
[ ] tratado
[ ] intentado

El acceso a los mismos quedará ______ (12) para evitar el deterioro de las obras.
[ ] disminuido
[ ] escaso
[ ] restringido

Por otra parte, se ______ (13), en los talleres de grabado y litografía,
[ ] darán
[ ] enseñarán
[ ] dirán

cursos ______ (14) las distintas técnicas de estampación.
[ ] sobre
[ ] en
[ ] para

Estos talleres también se cederán periódicamente a distintos artistas contemporáneos,
_______ (15)
[ ] ya que
[ ] así
[ ] para
se busca que el "Territorio Miró" ______ (16) un centro vivo de creación
[ ] será
[ ] sea
[ ] es

y difusión del arte a todos los ______ (17).
[ ] casos
[ ] aspectos
[ ] niveles

La entrada costará 500 pesetas y las previsiones dadas a conocer ayer aspiran ______ (18) que el centro acoja a unos 150.000 visitantes al año.
[ ] a
[ ] de
[ ] para

Los responsables esperan que la institución funcione a ______ (19) rendimiento
[ ] total
[ ] pleno
[ ] entero

a principios de la ______ (20) semana, si bien el catálogo completo de las obras de la Fundación Pilar y Joan Miró no estará listo hasta dentro de dos años.
[ ] siguiente
[ ] próxima
[ ] pasada
Assinale as respostas corretas.

1) – Dona Sílvia, ______________ é casada?
– Sim, sou casada e tenho três filhos.
[ ] você
[ ] a senhora
[ ] o senhor

2) – Oi João, __________ foi à escola ontem.
– Sim, eu tive teste de Português e Redação.
[ ] você
[ ] a senhora
[ ] o senhor

3) – __________ foi à reunião, doutor Paulo?
– Tive um atraso, mas cheguei a tempo da votação.
[ ] você
[ ] a senhora
[ ] o senhor

4) – Carla _________ muito nervosa. O que há de errado?
– São as preocupações no trabalho.
[ ] está
[ ] é
[ ] ser

5) - Cecília e eu _________ brasileiras.
- Brasileiras! Que legal! Eu visitei o Brasil no verão passado.
[ ] é
[ ] sou
[ ] somos

6) – Júlio, esta mala é de Mário?
– Não, é minha. A______________ está no quarto.
[ ] dela
[ ] seu
[ ] dele
7) – Eles _________ o jogo de futebol ontem?
– Sim, de dois a zero.
[ ] ganha
[ ] ganharão
[ ] ganharam

8) – Você trancou a porta?
– Claro, _________ sim.
[ ] trancamos
[ ] tranquei
[ ] trancou

9) – Marta, você _________ os documentos que lhe pedi?
– Sim, eles estão no seu escritório.
[ ] traz
[ ] trouxe
[ ] trazer

10) – Seu namorado _________ de feijoada?
– Muito, ele sempre me pede para fazer feijoada no fim de semana.
[ ] gostou
[ ] gostar
[ ] gosta

11) A festa será no salão, para _________ os convidados se dirigirão.
[ ] que
[ ] onde
[ ] a qual

12) – Pedro, onde _________ os livros que lhe emprestei?
– Sinto muito, deixei-os em casa.
[ ] são
[ ] estão
[ ] está

13) O assunto sobre _________ discutimos é sigiloso.
[ ] o qual
[ ] quem
[ ] cujo
14) - Quem ________ aqui em casa ontem?  
- Meu amigo de São Paulo e a esposa dele.  
[ ] está  
[ ] esteve  
[ ] estará  

15) – Cris vai construir uma casa ______ praia do Forte.  
– Que legal!  
[ ] na  
[ ] no  
[ ] da  

16) - O equipamento que veio ________ Japão já está em São Paulo.  
- Ótimo, podemos começar a reforma.  
[ ] do  
[ ] da  
[ ] no  

17) O quarto, ____________ janela dá para rua, é o maior da casa.  
[ ] cuja  
[ ] a qual  
[ ] que  

18) - Como você ________ para a Alemanha?  
- Viajamos de avião até Paris e depois pegamos um trem.  
[ ] vim  
[ ] vir  
[ ] veio  

19) – Amanhã, eu ____________ na praia.  
– Se eu não tiver que estudar, eu irei com você.  
[ ] vou nadar  
[ ] ir nadar  
[ ] vai nadar  

20) – Paulo _________ todo ano a Londres.  
– Mesmo!? Ele tem parentes lá?  
[ ] viaja  
[ ] viajar  
[ ] viajou
21) – Eu tenho que fazer ________ coisa para reconquistar Mariana.
   – Eu também acho, ela é uma mulher maravilhosa e você não pode perdê-la.
   [ ] algo
   [ ] nenhuma
   [ ] alguma

22) – Quem apagou a luz? Não estou vendo _________.
   – Ninguém a apagou, foi um black-out.
   [ ] tudo
   [ ] nada
   [ ] nenhum

23) – Maria viaja ____________ a irmã.
   – Ela realmente trabalha muito, mas em compensação ela ganha muito bem.
   [ ] mais do que
   [ ] maior do que
   [ ] muito mais

24) – Este livro é ____________ aquele.
   – Porém, este é mais divertido.
   [ ] mais melhor que
   [ ] mais bom que
   [ ] tão bom quanto

25) – Bia, você me ________ um favor? Coloque esses livros ali na estante.
   – Claro, com todo prazer.
   [ ] faz
   [ ] fazer
   [ ] fiz

26) – Tia Maria chegará da Europa, amanhã.
   – Ótimo, nós iremos ______________, no sábado.
   [ ] visitá-la
   [ ] a visitar
   [ ] visitar

27) – As novas professoras ainda não ________ conhecem.
   – Vamos lá, vou ________________a vocês.
   [ ] nos – apresentá-las
   [ ] me – lhes apresentar
   [ ] lhe – apresentar
28) Melissa, __________ você não quer ir comigo, vou ao Festival sozinha.
[ ] já que
[ ] mesmo que
[ ] embora

29) __________ eu gosto muito de Ivete Sangalo, eu não tenho dinheiro para ir ao show dela.
[ ] caso
[ ] embora
[ ] mesmo que

30) __________ Pedrinho prometa que irá se comportar, nunca mais irei sair com ele.
[ ] à proporção que
[ ] enquanto
[ ] a não ser que

31) - Você sabia que todos os anos, mais de 500 sacolas __________ no metrô de São Paulo?
- Mesmo?! E quantas pessoas voltam, para buscá-las?
[ ] esqueceram
[ ] foram esquecidas
[ ] são esquecidas

32) __________ o novo professor chegar, avise-me para que eu possa lhe dar as boas vindas.
[ ] a não ser que
[ ] enquanto
[ ] assim que

33) Tenho que andar __________! Já são 10 horas, e eu tenho que chegar ao trabalho às 10h15.
[ ] bem
[ ] rápido
[ ] lentamente

34) Infelizmente, a minha esposa cozinha muito __________, a comida dela é péssima.
[ ] mal
[ ] facilmente
[ ] bem
35) Tina, você não precisa pagar por estes produtos. Eles são distribuídos
[ ] silenciosamente
[ ] facilmente
[ ] gratuitamente

Assinale as respostas corretas.

Paulo viajará assim que (37) _____________ o contrato, ele (38) _____________ um aumento razoável se (39) _____________ um bom trabalho.

36) 
[ ] assinou
[ ] tiver assinado
[ ] teve assinado

37) 
[ ] receber
[ ] recebeu
[ ] receberá

38) 
[ ] fez
[ ] feito
[ ] fizer

Assinale as respostas corretas.

Sinto muito! Nós não (40) _____________ viajar neste fim de semana, tenho muito que (41) _____________ por isso, vou pedir que vocês me (42) _____________.

39) 
[ ] podíamos
[ ] poderemos
[ ] poderei

40) 
[ ] fiz
[ ] fazer
[ ] faz
Assinale as respostas corretas.

Gosto muito da Mônica, embora nós não nos (43) _________ muito bem, eu fico feliz que ela (44) _____________ no Vestibular.

42)  
[ ] conhecesse
[ ] conheçamos
[ ] conhecerei

43)  
[ ] passasse
[ ] passou
[ ] tenha passado

Assinale as respostas corretas.

Eles foram à Argentina, no inverno, para que as crianças (45) _____________ na neve.

44)  
[ ] brincarem
[ ] brincasse
[ ] brincassem
Leia os textos abaixo e selecione a alternativa correta.


45)  
[ ] As aulas não são pagas.  
[ ] As aulas são dadas todos os dias da semana.  
[ ] As aulas acontecem nos turnos da manhã e da tarde.

46)  
[ ] Você precisa pagar uma taxa para participar das aulas.  
[ ] Na praia, as pessoas não só praticam esportes como também fazem ginástica.  
[ ] O Tai-Chi-Chuan não está sendo muito praticado nas praias de Ipanema.

Pesquisa concluída recentemente sobre os hábitos da família paulistana diante da TV indicou que a maioria das famílias da cidade assiste televisão em grupo. O hábito familiar de reunir-se diante da televisão é mais forte durante a semana: quase metade dos entrevistados diz que sempre vê televisão com os filhos de segunda à sexta-feira, enquanto um terço das famílias o faz aos sábados. Aos domingos, o número sobe para 41%. O costume da reunião familiar na frente da televisão é mais acentuado nas famílias de classes sociais menos favorecidas (C,D,E): 56% delas assistem TV em grupo sempre, durante a semana. Das famílias de maior renda, 35% mantêm esse hábito nos dias de semana, enquanto das famílias de classe B, 43%. Fatores como espaço físico doméstico, além da variedade de ocupação e de lazer, diferentes em cada classe social, devem influir diretamente nesses resultados.

47)  
[ ] A pesquisa foi feita em várias cidades do Brasil.  
[ ] A classe social não interferiu no resultado da pesquisa.  
[ ] O número de pessoas que assistem televisão em grupo aos sábados, é menor do que aos domingos.

48)  
[ ] Todas as famílias paulistanas assistem televisão em grupo.  
[ ] Geralmente, as famílias se reúnem mais para assistir televisão nos fins de semana.  
[ ] Diferentes ocupações e as opções de lazer são algumas variáveis que influenciaram os resultados.
Uma baleia jubarte passou 14 horas encalhada ontem na praia de Bonete, em Ubatuba (233 km de São Paulo), no litoral norte. O animal só foi devolvido ao mar em uma operação que envolveu cerca de cem pessoas, entre o corpo de bombeiros, moradores e policiais florestais e oceanógrafos do Projeto Tamar (Tartaruga Marinha). A baleia, de cerca de 11 metros e 10 toneladas de peso, foi considerada subadulta. Uma baleia jubarte adulta chega a 15 metros. As jubartes costumam migrar da Antártida para passar o período verão no arquipélago de Abrolhos, na costa da Bahia.

A baleia encalhou na praia, às 2 horas da manhã de ontem. Ao amanhecer, pescadores tentaram levá-la de volta ao mar, mas o animal ficou preso na areia e não conseguia nadar. Técnicos do Projeto Tamar e do Corpo de Bombeiros chegaram à praia por volta das 11h para iniciar a operação de desencalhe. Um cabo de nylon preso ao animal foi puxado por um barco até uma profundidade em que a baleia pudesse nadar. Um navio rebocador guiou-a para alto mar. Ricardo Ota, oceanógrafo do Aquário de Ubatuba, disse que existem hipóteses para o encalhe: a baleia pode ter se chocado com um navio, ter contraído um parasita que afetou o seu sentido de direção ou mesmo ter perdido a rota quando procurava alimento.

(texto adaptado do jornal Folha de São Paulo, 04/11/2005)

49) [ ] A baleia jubarte encalhou na Baía de Todos os Santos.
[ ] Os técnicos afirmaram que a baleia jubarte encalhou por ter se chocado com um navio.
[ ] A equipe do projeto Tamar não foi a única responsável pela operação de salvamento.

50) [ ] A praia de Bonete fica na cidade de São Paulo.
[ ] A primeira tentativa para salvar a baleia foi feita pelos pescadores, mas eles não tiveram sucesso.
[ ] O animal encalhado foi considerado um filhote de baleia jubarte.

51) [ ] Não foi possível afirmar precisamente o que levou a animal a encalhar.
[ ] Depois de muitas tentativas, os pescadores guaram a baleia até alto-mar.
[ ] A baleia media onze metros e pesava onze toneladas.

CATEGORIAS: Classifique as palavras abaixo de acordo com a categoria correta.

52) mamão
[ ] Partes da casa
[ ] Profissão
[ ] Fruta ou verdura
[ ] Objetos
[ ] Estabelecimento
53) dentista
[ ] Partes da casa
[ ] Profissão
[ ] Fruta ou verdura
[ ] Objetos
[ ] Estabelecimento

54) sofá
[ ] Partes da casa
[ ] Profissão
[ ] Fruta ou verdura
[ ] Objetos
[ ] Estabelecimento

55) cozinha
[ ] Partes da casa
[ ] Profissão
[ ] Fruta ou verdura
[ ] Objetos
[ ] Estabelecimento

56) lápis
[ ] Partes da casa
[ ] Profissão
[ ] Fruta ou verdura
[ ] Objetos
[ ] Estabelecimento

57) advogado
[ ] Partes da casa
[ ] Profissão
[ ] Fruta ou verdura
[ ] Objetos
[ ] Estabelecimento
58) cenoura
[ ] Partes da casa
[ ] Profissão
[ ] Fruta ou verdura
[ ] Objetos
[ ] Estabelecimento

59) quarto
[ ] Partes da casa
[ ] Profissão
[ ] Fruta ou verdura
[ ] Objetos
[ ] Estabelecimento

60) banheiro
[ ] Partes da casa
[ ] Profissão
[ ] Fruta ou verdura
[ ] Objetos
[ ] Estabelecimento

61) médico
[ ] Partes da casa
[ ] Profissão
[ ] Fruta ou verdura
[ ] Objetos
[ ] Estabelecimento

62) farmácia
[ ] Partes da casa
[ ] Profissão
[ ] Fruta ou verdura
[ ] Objetos
[ ] Estabelecimento
63) caderno
[ ] Partes da casa
[ ] Profissão
[ ] Fruta ou verdura
[ ] Objetos
[ ] Estabelecimento
64) cantor
[ ] Partes da casa
[ ] Profissão
[ ] Fruta ou verdura
[ ] Objetos
[ ] Estabelecimento
65) melancia
[ ] Partes da casa
[ ] Profissão
[ ] Fruta ou verdura
[ ] Objetos
[ ] Estabelecimento
66) cebola
[ ] Partes da casa
[ ] Profissão
[ ] Fruta ou verdura
[ ] Objetos
[ ] Estabelecimento
67) cama
[ ] Partes da casa
[ ] Profissão
[ ] Fruta ou verdura
[ ] Objetos
[ ] Estabelecimento
68) padaria
[ ] Partes da casa
[ ] Profissão
[ ] Fruta ou verdura
[ ] Objetos
[ ] Estabelecimento

69) gabinete
[ ] Partes da casa
[ ] Profissão
[ ] Fruta ou verdura
[ ] Objetos
[ ] Estabelecimento

70) morango
[ ] Partes da casa
[ ] Profissão
[ ] Fruta ou verdura
[ ] Objetos
[ ] Estabelecimento

71) lanchonete
[ ] Partes da casa
[ ] Profissão
[ ] Fruta ou verdura
[ ] Objetos
[ ] Estabelecimento

VERBOS: Indique qual o verbo adequado que antecede as palavras/expressões abaixo.

72) _________ a liberdade de
[ ] ficar
[ ] tomar
[ ] fazer
[ ] dar
73) ________ ônibus
[ ] ficar
[ ] tomar
[ ] fazer
[ ] dar

74) ________ atenção a alguém
[ ] ficar
[ ] tomar
[ ] fazer
[ ] dar

75) ________ uma medida
[ ] ficar
[ ] tomar
[ ] fazer
[ ] dar

76) ________ de conta
[ ] ficar
[ ] tomar
[ ] fazer
[ ] dar

77) ________ nervoso
[ ] ficar
[ ] tomar
[ ] fazer
[ ] dar

78) ________ comentários
[ ] ficar
[ ] tomar
[ ] fazer
[ ] dar
79) _________ zangado
[ ] ficar
[ ] tomar
[ ] fazer
[ ] dar

80) _________ bem
[ ] ficar
[ ] tomar
[ ] fazer
[ ] dar

81) _________ parabéns
() ficar
[ ] tomar
[ ] fazer
[ ] dar

82) _________ bom-dia
[ ] ficar
[ ] tomar
[ ] fazer
[ ] dar

83) _________ gripado
[ ] ficar
[ ] tomar
[ ] fazer
[ ] dar

84) _________ anos
[ ] ficar
[ ] tomar
[ ] fazer
[ ] dar
85) ___________ grávida
[ ] ficar
[ ] tomar
[ ] fazer
[ ] dar

86) ___________ exercícios
[ ] ficar
[ ] tomar
[ ] fazer
[ ] dar

COMPREENSÃO ORAL - Clicando aqui, abrirá uma nova página com áudio. Escute uma parte de uma entrevista com uma advogada paulista comentando sobre o status das mulheres no Brasil. A seguir, você vai ouvir 6 afirmações sobre o mesmo tema. Baseando-se nas declarações da advogada, indique se as afirmações são verdadeiras ou falsas.

1. [ ] verdadeiro
   [ ] falso

2. [ ] verdadeiro
   [ ] falso

3. [ ] verdadeiro
   [ ] falso

4. [ ] verdadeiro
   [ ] falso

5. [ ] verdadeiro
   [ ] falso

6. [ ] verdadeiro
   [ ] falso
Agora, clique aqui para ouvir a entrevista de novo. Depois, indique se as afirmações que seguem são verdadeiras ou falsas.

7. A situação da mulher no Brasil avançou bastante nos últimos anos.
   [ ] verdadeiro
   [ ] falso

8. Homens e mulheres trabalham na delegacia das mulheres.
   [ ] verdadeiro
   [ ] falso

9. O apoio psicológico é oferecido àqueles que cometem agressões domésticas.
   [ ] verdadeiro
   [ ] falso

10. A licença maternidade foi reduzida de 120 para 90 dias.
    [ ] verdadeiro

11. A delegacia oferece abrigo às mulheres e seus filhos.
    [ ] verdadeiro
    [ ] falso
APPENDIX D
FOREIGN ACCENTEDNESS RATER INSTRUCTIONS

Ud. va a escuchar una serie de 42 muestras de español. Los hablantes son una mezcla de hablantes nativos y no nativos de español. El propósito de su evaluación es de juzgar el grado de acento extranjero de cada hablante.

Preste atención solamente al acento, ignorando los otros elementos del habla de cada hablante (velocidad de habla, fluidez, vocabulario, gramática, etc.)

Procedimiento:

1) Antes del inicio de cada muestra, Ud. va a oír una señal que indica el comienzo de la muestra.

2) Después de cada muestra, tendrá solamente 7 segundos para juzgar el grado de acento extranjero del hablante, insertando una nota en la hoja de cálculo abajo. Es importante que registre su primera percepción; entonces no escuche ninguna muestra más de una vez.

Como juzgar las muestras: Utilice una escala de 1 a 7 para juzgar el acento de cada hablante donde 1 = habla con un acento extranjero muy fuerte y 7 = no tiene acento extranjero; es hablante nativo de español. OJO: Use la escala entera!

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<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
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<tr>
<td>Habla con un acento extranjero muy fuerte</td>
<td>Habla con acento extranjero</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No tiene acento extranjero – Es hablante nativo de español</td>
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<table>
<thead>
<tr>
<th>Hablante</th>
<th>Nota</th>
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<tr>
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</tr>
<tr>
<td>2</td>
<td></td>
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</tbody>
</table>

Figure D-1. Screen shot of foreign accentedness rater spreadsheet (SP)
Translation of instructions:

You will hear a series of 42 samples of Spanish speech. The speakers are a combination of native speakers and non-native speakers of Spanish. The purpose of the evaluation is to judge the degree of foreign accent of each speaker. Pay attention only to foreign accent, ignoring the other elements of speech (speech rate, vocabulary, grammar, etc. Procedure: 1) Before each sample, you will hear a beep that will indicate the beginning of the sample. 2) After each sample, you will have only seven seconds to judge the degree of foreign accent of the speaker, inserting your
score into the spreadsheet below. It is important that you note your initial impression, so do not
listen to each sample more than once. How to judge the samples: Use a scale from one to seven
to judge each speaker’s foreign accent, where 1 = very strong foreign accent, 4 = noticeable
foreign accent, and 7 = no foreign accent; is definitely a native speaker.
En esta parte del estudio, Ud. va a oír una frase, seguida de una pregunta. Conteste la pregunta, repitiendo la frase original entera cuando lo haga.

Los próximos 5 artículos son una práctica.

Preste atención, pues sólo puede hacer la práctica una vez.

<Oprima cualquier botón para comenzar la práctica.>

Em esta parte da pesquisa, você vai ouvir uma frase, seguida por uma pergunta. Responda a pergunta, repetindo a frase original inteira.

Vamos praticar com 5 itens.

Preste atenção, pois só pode fazer a prática uma vez.

<Aperte qualquer botão para começar a prática.>

Figure E-1. Delayed repetition task instructions screen in Spanish and BP (as presented by E-Prime).
Figure E-2. Goodness task instructions screen in Spanish and BP (as presented by E-Prime).

**Translation of instructions:** In this part of the study, you will hear a series of pairs of phrases in Spanish/Portuguese. The two phrases are the same, except for the last word. Compare the two words and choose the one that sounds more natural in Spanish/Portuguese. If the first word
sounds more natural, press ‘1’. If the second word sounds more natural, press ‘2’. Now, we will practice with five items. <Press any button to continue.>
## APPENDIX F
### DELAYED REPETITION TASK STIMULI

Table F-1. Delayed repetition task critical trials.

<table>
<thead>
<tr>
<th>Input</th>
<th>Spanish stimuli</th>
<th>BP stimuli</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front vowel /e/ (n=10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>/fape/</td>
<td>[ˈfa.pe]</td>
<td>[ˈfa.pl]</td>
</tr>
<tr>
<td>/plake/</td>
<td>[ˈpla.ke]</td>
<td>[ˈpla.ki]</td>
</tr>
<tr>
<td>/trape/</td>
<td>[ˈtra.pe]</td>
<td>[ˈtra.pi]</td>
</tr>
<tr>
<td>/klafe/</td>
<td>[ˈkla.fe]</td>
<td>[ˈkla.fi]</td>
</tr>
<tr>
<td>/male/</td>
<td>[ˈma.le]</td>
<td>[ˈma.li]</td>
</tr>
<tr>
<td>/nafe/</td>
<td>[ˈna.fe]</td>
<td>[ˈna.fi]</td>
</tr>
<tr>
<td>/kafre/</td>
<td>[ˈka.fre]</td>
<td>[ˈka.frı]</td>
</tr>
<tr>
<td>/flake/</td>
<td>[ˈfla.ke]</td>
<td>[ˈfla.ki]</td>
</tr>
<tr>
<td>/pakle/</td>
<td>[ˈpa.kle]</td>
<td>[ˈpa.klı]</td>
</tr>
<tr>
<td>/lape/</td>
<td>[ˈla.pe]</td>
<td>[ˈla.plı]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Back vowel /o/ (n=10)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>/napo/</td>
<td>[ˈna.po]</td>
<td>[ˈna.po]</td>
</tr>
<tr>
<td>/kralo/</td>
<td>[ˈkra.lo]</td>
<td>[ˈkra.lı]</td>
</tr>
<tr>
<td>/tato/</td>
<td>[ˈta.to]</td>
<td>[ˈta.to]</td>
</tr>
<tr>
<td>/mafo/</td>
<td>[ˈma.fı]</td>
<td>[ˈma.food]</td>
</tr>
<tr>
<td>/fapo/</td>
<td>[ˈfa.po]</td>
<td>[ˈfa.po]</td>
</tr>
<tr>
<td>/plako/</td>
<td>[ˈpla.ko]</td>
<td>[ˈpla.ko]</td>
</tr>
<tr>
<td>/kafo/</td>
<td>[ˈka.fı]</td>
<td>[ˈka.food]</td>
</tr>
<tr>
<td>/lako/</td>
<td>[ˈla.ko]</td>
<td>[ˈla.ko]</td>
</tr>
<tr>
<td>/flato/</td>
<td>[ˈfla.to]</td>
<td>[ˈfla.to]</td>
</tr>
<tr>
<td>/paplo/</td>
<td>[ˈpa.plo]</td>
<td>[ˈpa.plo]</td>
</tr>
</tbody>
</table>
### Table F-2. Delayed repetition task filler trials.

<table>
<thead>
<tr>
<th>Spanish stimuli</th>
<th>BP stimuli</th>
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</thead>
<tbody>
<tr>
<td><strong>Legal complex onset, penultimate syllable (n=10)</strong></td>
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</tr>
<tr>
<td>['fra.na]</td>
<td>['fra.na]</td>
</tr>
<tr>
<td>['fra.ya]</td>
<td>['fra.ya]</td>
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<td>['fra.mo]</td>
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<td>['fre.na]</td>
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<td>['fra.po]</td>
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<td>['pra.ma]</td>
<td>['pra.ma]</td>
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<tr>
<td>['pro.ma]</td>
<td>['pro.ma]</td>
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<tr>
<td>['pra.mo]</td>
<td>['pra.mo]</td>
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<td>['pra.ke]</td>
</tr>
<tr>
<td>['pre.ʃo]</td>
<td>['pre.ʃo]</td>
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<tr>
<td><strong>Legal complex onset, final syllable (n=10)</strong></td>
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<td>['tas.fra]</td>
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<td>['las.fra]</td>
<td>['las.fra]</td>
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<td>['pas.pra]</td>
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<tr>
<td>['kas.pra]</td>
<td>['kas.pra]</td>
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<tr>
<td><strong>Legal nasal consonant coda (n=20)</strong></td>
<td><strong>Legal nasal nucleus (n=20)</strong></td>
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<tr>
<td>['paŋ.fo]</td>
<td>['paŋ.fo]</td>
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<td>['miŋ.ke]</td>
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<td>['liŋ.ka]</td>
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<tr>
<td>['laŋ.ta]</td>
<td>['laŋ.ta]</td>
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<td>['biŋ.ta]</td>
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<td>['liŋ.ko]</td>
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<tr>
<td>Legal nasal consonant coda (n=20)</td>
<td>Legal nasal nucleus (n=20)</td>
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<td>---------------------------</td>
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<td>['mʊpə]</td>
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<td>['pʊ.to]</td>
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### Table G-1. Goodness task critical trials

<table>
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<tr>
<th>Option A</th>
<th>Option B</th>
<th>Correct answer SP</th>
<th>Correct answer BP</th>
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<tbody>
<tr>
<td>Front vowel /e/ (n=10)</td>
<td></td>
<td></td>
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<tr>
<td>[ˈfa.pe]</td>
<td>[ˈfa.pɪ]</td>
<td>A</td>
<td>B</td>
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<td>[ˈpla.ke]</td>
<td>[ˈpla.kɪ]</td>
<td>A</td>
<td>B</td>
</tr>
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<td>[ˈtra.pe]</td>
<td>[ˈtra.pɪ]</td>
<td>A</td>
<td>B</td>
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<tr>
<td>[ˈkla.fe]</td>
<td>[ˈkla.fɪ]</td>
<td>A</td>
<td>B</td>
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<tr>
<td>[ˈma.le]</td>
<td>[ˈma.lɪ]</td>
<td>A</td>
<td>B</td>
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<td>[ˈna.fɪ]</td>
<td>A</td>
<td>B</td>
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<tr>
<td>[ˈka.fre]</td>
<td>[ˈka.fɾɪ]</td>
<td>A</td>
<td>B</td>
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<td>[ˈfla.ke]</td>
<td>[ˈfla.kɪ]</td>
<td>A</td>
<td>B</td>
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<td>[ˈpa.kle]</td>
<td>[ˈpa.klɪ]</td>
<td>A</td>
<td>B</td>
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<td>[ˈla.pe]</td>
<td>[ˈla.pɪ]</td>
<td>A</td>
<td>B</td>
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<td>Back vowel /o/ (n=10)</td>
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<td>[ˈna.po]</td>
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<td>[ˈta.to]</td>
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<td>B</td>
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<td>B</td>
</tr>
<tr>
<td>[ˈpa.plo]</td>
<td>[ˈpa.plo]</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Option A</td>
<td>Option B</td>
<td>Correct answer</td>
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<td>SP</td>
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</tbody>
</table>

Table G-2. Goodness task filler trials

Legal/illegal coda (SP) and nucleus/coda (BP) (n=10)

<table>
<thead>
<tr>
<th>Option A</th>
<th>Option B</th>
<th>Correct answer</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

Legal/illegal complex onset, penultimate syllable (n=8)

<table>
<thead>
<tr>
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<th>Option B</th>
<th>Correct answer</th>
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</tr>
</tbody>
</table>

Legal/illegal complex onset, final syllable (n=7)

<table>
<thead>
<tr>
<th>Option A</th>
<th>Option B</th>
<th>Correct answer</th>
</tr>
</thead>
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BIOGRAPHICAL SKETCH

Jennifer Cabrelli Amaro holds a PhD in Hispanic Linguistics from the University of Florida, an MA in Spanish from Middlebury College in Spain, and a BA in Spanish from Michigan State University (Phi Beta Kappa). Her primary research interest is language acquisition, specifically the acquisition of Spanish and Brazilian Portuguese (BP) phonology and morphosyntax. Recent articles have appeared in the journals *Second Language Research*, *International Review of Applied Linguistics*, and *Studies in Hispanic and Lusophone Linguistics*, as well as chapters in volumes published by De Gruyter, John Benjamins, and Cambridge University Press.