

Article

Modeling Heritage Language Phonetics and Phonology: Toward an Integrated Multilingual Sound System

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Abstract: Although heritage language phonology is often argued to be fairly stable, heritage language speakers often sound noticeably different from both monolinguals and second-language learners. In order to model these types of asymmetries, I propose a theoretical framework—an integrated multilingual sound system—based on modular representations of an integrated set of phonological contrasts. An examination of general findings in laryngeal (voicing, aspiration, etc.) phonetics and phonology for heritage languages shows that procedures for pronouncing phonemes are variable and plastic, even if abstract may representations remain stable. Furthermore, an integrated multilingual sound system predicts that use of one language may require a subset of the available representations, which illuminates the mechanisms that underlie phonological transfer, attrition, and acquisition.

Keywords: heritage languages; universal multilingualism; phonetics; phonology; contrast; transfer; attrition



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1. Introduction

Heritage language (HL) sound patterns are strikingly heterogeneous and often prone to gradient changes over the lifespan (Chang 2019a; de Leeuw and Celata 2019). Yet they also typically reflect the maintenance of core phonological systems (e.g., Oh et al. 2003; Polinsky 2018). Especially since Benmamoun et al. (2013) heritage languages have been thrust into serious theoretical investigation and at that time, work on HL sound systems lagged behind morphosyntactic analyses. In the almost decade since, serious progress has been made by investigating patterns in heritage language speech sounds, and examining how they relate to both the majority contact languages and comparison groups of monolinguals or multiple generations of bilinguals (Nagy and Kochetov 2013; Nodari et al. 2019; Vanhecke and Hietpas 2021). Still, considerable work remains to fully integrate those findings into core phonological theorizing. My goal here is to take a step in that direction. By highlighting the gains made in understanding HL and bilingual phonetics and phonology, I show that consolidating these and similar findings into an integrated multilingual sound system provides a viable framework for modeling HL phonetic and phonological patterns. I evaluate what phonetic variation does and does not (necessarily) tell us about HL phonology and outline how this theorizing provides clear questions to pursue to mutually deepen our understanding of phonology, multilingualism, and heritage languages.

I adopt a broad understanding of HL and heritage language speakers (HSs), based on the social and linguistic conditions under which the language is acquired:

A heritage speaker (HS) is a bilingual who has acquired a family... and a majority societal language naturalistically in early childhood. To qualify as HS bilingualism, acquisition crucially must take place in a situation where the home language is decisively not the language of the greater society. (Pascual y Cabo and Rothman 2012, p. 451)

In the exposition of this model, I assume, as a point of departure, the acquisition of all relevant phonemic categories under discussion. These cases may be more common to

HSs who acquire the HL and majority language (MajL) simultaneously or sequentially as children, in contrast to adult language learners. However, the present framework is designed to account for a range of bilingual situations without stipulating fundamentally different grammatical properties. Although future work can explore these circumstances in more detail, I draw on an array of phonetic and phonological patterns to illustrate key aspects of the model.

Research on HL phonetics and phonology converges in finding asymmetric characteristics, especially with respect to how ‘stable’ or ‘vulnerable’ particular structures are to influence from the dominant language: “many phonological aspects of language develop quite early and seem to be salient under conditions of reduced exposure. . . others are vulnerable to restructuring and change under pressure from the dominant language” (Benmamoun et al. 2013, p. 141). HSs acquire their HL from heterogeneous input and use that potentially varies greatly in quality and quantity, and changes over a speaker’s lifespan (Pascual y Cabo and Rothman 2012; Putnam et al. 2018). Patterns of language use have also been shown to induce longitudinal changes in HL phonetics and phonology, highlighting the plasticity of HSs’ sound systems (de Leeuw and Celata 2019). These specific conditions lead to a range of outcomes, including grammatical transfer, language attrition, and divergent attainment (Polinsky and Scontras 2020). A key question for HL phonetics and phonology concerns which representations and processes are vulnerable and prone to these phenomena, which factors affect that division, and how these may change over the course of a speaker’s lifespan (e.g., Chang 2019b; Celata 2019; de Leeuw 2019; Natvig 2019).

The proposed framework for an integrated multilingual sound system assumes that HL bilingualism is one type of universal multilingualism (MacSwan 2017; Roeper 1999), where language is composed of “an integrated system of internally differentiated sub-components” (MacSwan 2017, p. 185) for multilinguals and monolinguals alike. I argue here that phonological representations belong to a unified grammatical architecture (cf. Kroll and Gollan 2014; Pickering and Garrod 2013; Putnam et al. 2018), but that distinct processes for realizing those structures may be differentiated and distributed across different languages and social contexts. Because variation and change result from interactions of both linguistic structures and social factors (e.g., Dorian 1993; Natvig and Salmons 2021; Salmons and Purnell 2020), gradient, variable, and asymmetric HL effects may emerge from changes in the use and activation of language-specific processes over speakers’ lifespans (Natvig 2019; Putnam et al. 2019).

Moreover, this model follows recent phonological work that adopts the modular design put forward in Purnell and Raimy (2015), and applied to contact phenomena in Natvig (2019, 2021), as a way forward in modeling the heterogeneity and plasticity of HL speech sounds. In these approaches, the sound system is organized into at least three subdomains, or modules, each with distinct representations and processes (see Section 2). Disambiguating distinct levels of representation in this way offers a cohesive framework for capturing the observation that HL sound patterns systematically differ from both first-language (L1) monolinguals and late-onset second language (L2) learners (e.g., Chang and Yao 2016; Kupisch et al. 2014) and for making testable predictions for the development of those patterns over time.

The remainder of the article is structured as follows: I discuss core theoretical desiderata in Section 2, focusing on laryngeal (voicing, aspiration, etc.) phonetics and phonology. In Section 3, I motivate a model for an integrated multilingual sound system, drawing particularly on voicing and aspiration patterns of Spanish-English bilinguals. I discuss antecedent HL studies using this model in Section 4. Then in Section 5, I contextualize the implications of approaching sound patterns through a modular, integrated multilingual system on our understanding of heritage language grammars. I conclude in Section 6.

2. Theoretical Framework: Contrast, Features, and Levels of Representation

A great deal of pioneering research on HL phonetics and phonology has focused on both surface-level patterns in speech (Bullock and Gerfen 2004a, 2004b; Godson 2004; Hrycyna et al. 2011) and perception abilities (Au et al. 2002; Lukyanchenko and Gor 2011; Oh et al. 2003; Chang 2016). These are of course critical components for understanding HL sound systems, and phonological systems generally. In order to make progress along this front, the particular characteristics of sound patterns need to be evaluated and analyzed for their effects on—and relationships with—other sounds and processes within the languages' abstract representational systems. Key to modeling phonetics and phonology is defining the properties and scope of the *phonology*, and clearly outlining the relationship between phonetic outputs and their corresponding representations. In an integrated phonology, some, but not necessarily all, features may be shared across multiple languages. Although there has been and continues to be considerable debate on the nature of the relationship between phonetics and phonology, including if there even is a difference between the two (Hayes et al. 2004; Ladd 2014; Ohala 1990; Hale and Reiss 2000; Purnell 2009; Reiss 2017), the following points inform the model of an integrated multilingual sound system proposed here:

- Phonetics is typified by continuous, gradient properties, whereas the phonology consists of discrete, distinctive categories (Hall 2020, 2011). Therefore, each module deals in different representation types that reflect those properties (Purnell and Raimy 2015).
- Phonological representations are language-specific collections of relevant properties. They are not themselves percepts, sounds, nor abstractions of specific sounds like IPA symbols (Dresher 2014; Trubetzkoy 1939).
- Phonological representations *constrain* potential articulatory and acoustic realizations of speech sounds, of which there are often many potential variants (Avery and Rice 1989; Dresher 2009; Dresher et al. 1994; Natvig 2020).
- Phonetics is 'richer' than phonology, meaning that multiple acoustic cues may correspond to a single, relevant distinction. Accordingly, the phonology is *underspecified* relative to measurable outputs in speech production data.

There are numerous models for capturing these patterns. I demonstrate these points with dimensional feature theory (Ahn and Iverson 2004; Avery and Idsardi 2001; Natvig 2020; Purnell 2017; Purnell and Raimy 2015) using 'Modified Contrastive Specification' (MCS; Dresher 2009; Dresher et al. 1994) as the overarching theoretical framework (see Section 2.1). I focus here on laryngeals, the acoustic characteristics that are commonly measured and analyzed using voice onset time (VOT), although other features may be relevant in certain contexts (e.g., Kingston and Diehl 1994). VOT is a measure of the relationship between the stop burst and the start of vocal fold vibration. Lead VOT (occurring prior to the burst) indicates voicing, short-lag VOT (occurring approximately 0–30 ms after the burst) indicates voiceless/plain stops,¹ and long-lag VOT (occurring more than 30 ms after the burst) indicates aspiration. I examine languages in contact that have, among monolinguals, different representational strategies for marking the relevant natural classes. Work on laryngeal patterns, both cross-generationally (Nagy and Kochetov 2013; Kang and Nagy 2016; Nodari et al. 2019; Vanhecke and Hietpas 2021) and longitudinally (Chang 2012, 2013, 2019a; Llandos and Francis 2017), provides an ideal point of departure for illustrating a model of integrated phonological representations.

2.1. Contrast and Representations

Fundamentally, the phonology is a system of contrasts that consists of the relevant properties that distinguish meaningful sound categories (Dresher et al. 1994; Dresher 2009; Hall 2011; Trubetzkoy 1939). It is therefore necessary to disambiguate a speech sound from its corresponding phoneme, the latter being an abstract category that corresponds to "sounds [that] participate in phonological (distinctive) oppositions only by means of their phonologically relevant properties" (Trubetzkoy 1939, p. 36). With respect to HL bilinguals,

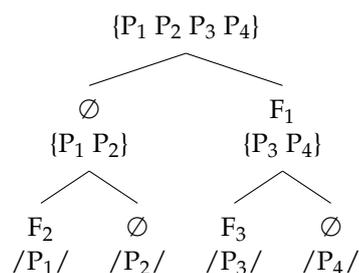
distinguishing sounds from phonemes involves examining how distinctive oppositions from multiple languages interact to influence surface-level characteristics of speech sounds.

Contrast is the foundation of MCS (Dresher 2009; Dresher et al. 1994), which proposes that the phonology consists only of features that mark language-specific relevant distinctions (Avery and Rice 1989; Hall 2011; Natvig 2020). A fundamental principle in MCS is formulated as the ‘contrastivist hypothesis’ (Hall 2007), which posits that a given language’s phonological processes only manipulate features that distinguish the phonemes of that language. These features are acquired from generalizing abstract representations based on systematic distinctions in the linguistic input:

phonology takes substance from outside FLN [narrow faculty of language] and converts it to objects that can be manipulated by the linguistic computational system. (Dresher 2014, p. 177)

Accordingly, active phonological processes involving particular characteristics provide evidence for the presence of that feature in contrastive representations. In MCS, features divide a phonemic inventory feature-by-feature, until each phoneme is distinct, in a ‘contrastive hierarchy’ (Dresher 2009). A sample contrastive hierarchy is provided in (1), using a privative contrast based on the presence (F) vs. the absence (\emptyset) of a feature (for arguments see (Avery and Idsardi 2001; Iverson and Salmons 1995; Purnell and Raimy 2015; Natvig 2020, 2021; Purnell et al. 2019). The relevant phonological properties (F_1 , F_2 , and F_3) divide the phonemic inventory ($/P_1 P_2 P_3 P_4/$) one feature at a time until each phoneme is uniquely specified, a procedure that Dresher (2009, p. 16) refers to as the “Successive Division Algorithm” or SDA. Note that F_2 and F_3 need not be different features, but that each feature can only be applied once to any given set or subset of phonemes. These features, as well as their order and the classes of phonemes they specify, may differ from language to language. Cross-linguistically, the same or similar speech sounds may have different abstract representations (Mackenzie 2011, 2013), and phonemes with the same contrastive feature configurations may be implemented with different phonetic forms (Natvig 2020). Furthermore, both of these types of asymmetries between the phonology and the phonetics may apply for multilingual individuals and populations (see Section 4).

(1) Example Contrastive Hierarchy



2.2. Feature Content

Because phonemes are collections of contrastive features, they are not pronounceable in and of themselves. They must be rendered pronounceable through additional operations. In their analysis of the content of distinctive features, Avery and Idsardi (2001) capture this distinction by arguing that the phonology operates on abstract nodes that are completed with articulatory gestures. Some gestures, for example [spread] glottis and [constricted] glottis, cannot occur simultaneously in speech because they are antagonistic pairs within a single muscle group. For one of the gestures to be activated, its pair must be inhibited (Avery and Idsardi 2001, p. 44). Because this antagonism is subject to anatomical constraints and does not require linguistic knowledge, Avery and Idsardi (2001) argue that phonological representations consist of what they call ‘dimensions’, or organizations of mutually exclusive articulatory gestures, as in Figure 1.² For aspiration, the dimension

is Glottal Width (GW). Similarly, because a phone cannot be both voiceless and voiced, respectively [stiff] and [slack] vocal folds, these gestures are organized under the Glottal Tension (GT) dimension.

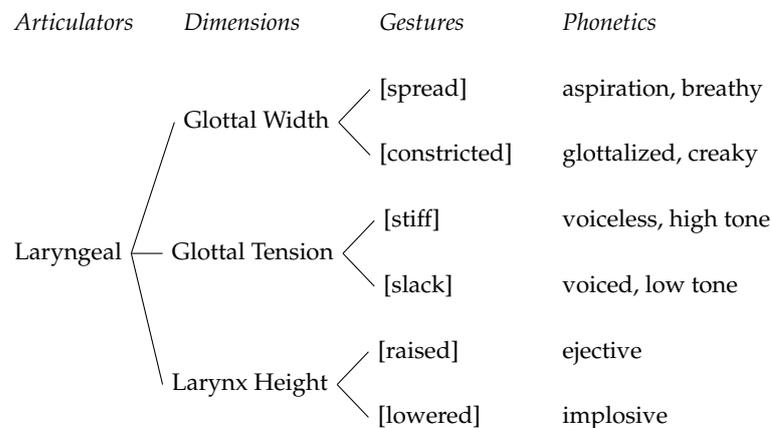


Figure 1. Laryngeal dimensions, completions, and phonetics (adapted from (Avery and Idsardi 2001, p. 42; Purnell and Raimy 2015, p. 526)).

The HL laryngeal patterns that are considered here demonstrate contact between languages that mark laryngeal contrasts using different dimensions, as shown in the contrastive hierarchies in (2): one type with GT, i.e., a ‘Voicing’ system as in (2a), and another type with GW, i.e., an ‘Aspirating’ system as in (2b). For the Voicing systems discussed here, GT is completed with the gesture [slack], which induces voicing. On the other hand, GW here is completed with [spread] for aspiration. Because phonological representations are underspecified relative to their potential phonetic signals, it is the evidence that GT or GW participate actively in the phonological computations, not necessarily the surface phonetics, that supports one type of system over the other. MCS with privative contrasts models this underspecification in two ways. First, phonemes are only marked for the substance that produces the appropriate distinctions for a given languages’ phonemic inventory. Second, privative marking provides the representation of ‘negative’ contrast. For both GT and GW systems, /p t k/ form a category based on exclusion. In a GT system like Spanish (2a), /p t k/ are not voiced, whereas in English (2b), /p t k/ are not aspirated; their surface forms, then, may present with a variety of characteristics so long as they remain distinct in some manner from those of the specified classes they contrast with (Hall 2011; Natvig 2020), barring additional neutralization processes (see Section 4.2).

(2) Voicing and Aspirating laryngeal representations



2.3. Levels of Representation and Contact Effects

A given phoneme may have a variety of potential variable surface forms depending on whether a particular property corresponds to contrastive or non-contrastive features (Natvig 2021; Natvig and Salmons 2021). We can understand these patterns through the steps in which abstract dimensions are rendered pronounceable (Purnell and Raimy 2015; Natvig 2019, 2021), as in the comparison of the contrast for Spanish and English in Table 1. Under this view, the sound system is organized into (1) Contrastive features (PHONOLOGY),

(2) Articulatory gestures (a PHONETICS-PHONOLOGY INTERFACE), and (3) Speech signal (PHONETICS). The PHONOLOGY operates on dimensions, which are completed with one of the two antagonistic gestures—GT → [slack] for Spanish and GW → [spread] for English—at the PHONETIC-PHONOLOGICAL level of representation. These gestures are implemented in real time in the PHONETICS as gradient, continuous properties, with measurable acoustics: here as lead VOT from [slack] (*voiced*) and long-lag VOT from [spread] (*aspirated*). In sum, the PHONOLOGY represents grammatical knowledge. It encodes contrasts, which both distinguish meaningful sound categories and provide units of structure for phonological computations. The PHONETICS-PHONOLOGY and PHONETICS, on the other hand, represent the procedural behaviors that speakers employ when assembling abstract categories with articulatory gestures and implementing those in real time. These procedures are grounded in the social behaviors that structure heterogeneous sound patterns (Natvig and Salmons 2021; Sonderegger et al. 2020; Weinreich et al. 1968), and are reinforced or adjusted through experience (following Bybee 2001; Goldinger 1996).

Table 1. Voicing and aspirating laryngeal representations and completions.

| | (2a) Spanish Voicing | | (2b) English Aspirating | |
|-----------|-----------------------------|----------------|--------------------------------|--|
| | /b d g/ | /p t k/ | /p t k/ | /p^h t^h k^h/ |
| PHONOLOGY | GT | ∅ | ∅ | GT |
| PHON-PHON | [slack] | | | [spread] |
| PHONETICS | <i>voiced</i> | <i>plain</i> | <i>plain</i> | <i>aspirated</i> |

Asymmetric patterns from language contact may emerge as a result of different levels of representation within a multilingual grammar being relatively more or less differentiated. For example, bilingualism often results in gradient changes in the acoustics of a given articulation, even in cases where speakers are more proficient in the recipient language. For example, Major (1992) finds decreases in the VOT of English speakers’ aspirated stops with fairly little exposure to Brazilian Portuguese, and studies on phonetic drift (e.g., Chang 2012, 2013, 2019a) find similar patterns. Because, for Major (1992), the gesture for aspiration ([spread]) is still produced, albeit for a shorter period of time, this represents a PHONETIC change. On the other hand, German speakers in the United States often produce an English-like approximant [ɹ] (Schmid 2011, pp. 51–52), introducing a new articulation—either retroflex or ‘bunched’ (Ladefoged and Maddieson 1996, pp. 234–35)—for the same /r/ phoneme (i.e., there is no evidence of a new phonemic contrast). This is a change at the PHONETICS-PHONOLOGY module, where new gestures that are not completions of contrastive dimensions enter the sound system. We can refer to these non-contrastive gestures as *enhancements* (Stevens et al. 1986; Hall 2011; Purnell and Raimy 2015).

As an example of a laryngeal enhancement, in many areas of the Southern United States, phonologically unspecified (plain) /p t k/ are fully voiced (Jacewicz et al. 2009; Walker 2020). However, this voicing does not participate in active phonological processes (e.g., assimilation) like aspiration does (Salmons 2020), indicating that GW and not GT remains the relevant contrastive dimension. Instead, voicing is a phonetic enhancement that increases the salience of the plain-aspirated contrast (Hall 2011; Stevens et al. 1986). English voicing enhancement is presented in Table 2, where the unmarked /p t k/ class (∅) in Southern American English (SAE), but not Northern American English (NAE), is completed with a [slack] gesture, with ‘+[slack]’ indicating an enhancement. These patterns, and examining them through a modular framework of the type presented here, further underscore the need to consider phonetic properties in the context of their behavior, i.e., whether they are active or inert in phonological computations. Although speakers of NAE and SAE may differ in their stop realizations, the fundamental organization of the contrastive system is the same.

Table 2. American English laryngeal representations, completions, and enhancements.

| | NAE | | SAE | |
|-----------|--------------|------------------|---------------|------------------|
| PHONOLOGY | ∅ | GW | ∅ | GW |
| PHON-PHON | | [spread] | + [slack] | [spread] |
| PHONETICS | <i>plain</i> | <i>aspirated</i> | <i>voiced</i> | <i>aspirated</i> |

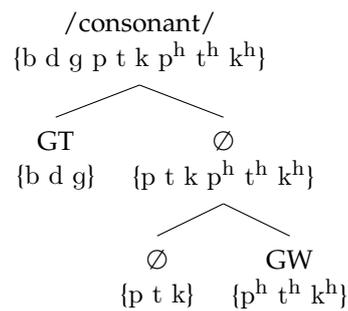
Finally, a change at the PHONOLOGICAL level involves added or lost contrasts, or a change in contrastive features for the contacting languages (Natvig 2019). Finding clear evidence if this is often challenging because it is not always clear whether the loss of a surface feature relates to a change in representations. For example, Joo et al. (2018) find evidence of a merger of /ɔ/ and /a/ in Moundridge Schweizer German, supporting the loss of a distinctive feature contrasting the two in the HL. However, there is some remaining distinction in the MajL, indicating the presence of the relevant contrast. Likewise, for some varieties of American Norwegian, the opposition between /y/ and /i/ appears to have changed from rounded-unrounded to lax-tense, such that /y/ occurs as /ɪ/ (Hjelde 1996). This difference may be consistent with a PHONOLOGICAL change in contrastive features. Yet, this newer /ɪ/ is produced with tense lips instead of lip rounding (Hjelde 1996, p. 289), which could indicate a change in the *completion* of a Labial dimension, i.e., a PHONETIC-PHONOLOGICAL difference in the HL. I leave this particular analysis to further investigation, but this issue concretely illustrates that the effects of HL bilingualism and language contact on the HL sound system can be ambiguous from surface patterns alone.

Independent of the number and content of abstract contrasts, phonological representations form the basis of a fully integrated system. Still, the procedures that convert phonemes into pronounceable forms may vary with respect to how similar they are to those for speakers in a baseline comparison group. The extent to which those language-specific processes are differentiated relates to a host of sociolinguistic and cognitive factors underlying language acquisition, use, and development across the lifespan.

3. Toward an Integrated Multilingual Sound System

Decades of psycholinguistic research has demonstrated simultaneous language activation among multilinguals (de Groot 2016; Grosjean 1989; Hartsuiker et al. 2004), supporting the position that, although there may be competing representations, bilingual grammars are shared, integrated systems (Cook 2016; Hsin 2014; Putnam et al. 2018). For phonology, I take as a point of departure that *all* contrasts, regardless of the language to which they originate, are represented within a single hierarchy of contrastive dimensions.³ In the context of universal multilingualism (MacSwan 2017; Roepers 1999), these contrastive representations are shared grammatical knowledge, whereas the procedures that they undergo may be differentiated across a variety of linguistic and social contexts. With respect to laryngeal contrasts, Spanish-English bilinguals, for example, have been shown to perceive voiced, plain, and aspirated consonants using language-specific categorization routines (Casillas and Simonet 2018; García-Sierra et al. 2012; Gonzales and Lotto 2013). This suggests that they draw on different representations based on language mode, i.e., interacting in Spanish or English. These findings support Spanish-English representations consisting of the integrated Voicing and Aspirating systems like those in (2), presented in the contrastive hierarchy in (3). For present purposes, I model the acquisition of the Voicing system, i.e., (2a), then through the process of acquiring the Aspiration (2b) system, /p t k/ are split into plain and aspirated categories with a GW specification.⁴

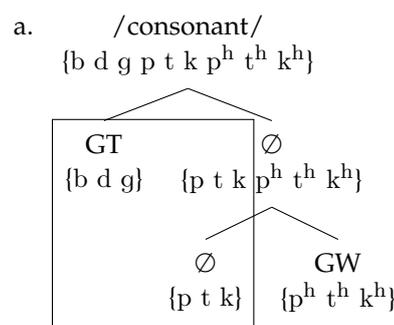
(3) Integrated Voicing and Aspirating laryngeal representations

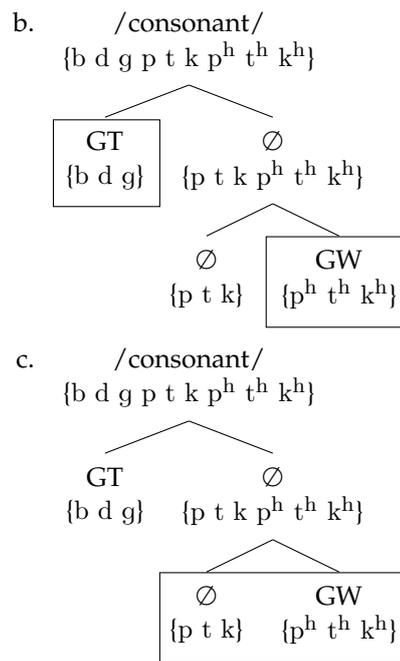


With an integrated system that contains both the Spanish and English laryngeal dimensions, speakers have at their disposal a superset of representations necessary for producing the contrasts of each language. Although these representations exist in a common cognitive space, the procedures they undergo may be variably differentiated across language modes (cf. MacSwan 2017) and subject to varying degrees of gradience (Goldrick et al. 2016). That is, the language-specific completions, enhancements, and phonetic implementations involved in producing these representations in speech have the potential to influence each other (Natvig 2019), which contributes to surface-level variability in (HL) bilingual laryngeal patterns (Amengual 2012; Casillas 2020; Kim 2011).

For a Heritage Spanish-English bilingual, three hypothetical alignments of these phonological contrasts are available for the /p t k/ – /b d g/ distinction, as in (4). I refer to these alignments as contrastive subsets. The structure presented in (4a) represents the utilization of representations that match the Spanish Voicing contrast. Evidence of activity in the heritage language requiring reference to /b d g/, specified for GT, and a phonologically inert class of /p t k/ stops supports this structure. This is the most Spanish-like configuration because it draws on the same two abstract categories in the HL that are available in the baseline grammar. On the other hand, for (4b), a speaker would implement a contrast based on the classes that are both specified for a laryngeal dimension, i.e., a contrast via the *phonologically* voiced and aspirated phonemes /b d g/ – /p^h t^h k^h/. Support for this may be difficult to uncover, although it would involve more or less categorical implementation of voicing and aspiration for the appropriate sets and clear evidence of both GT and GW activity. With only phonetic evidence, however, the surface forms of either may be due to enhancement of the plain /p t k/ category, either via voicing (4a) or aspiration (4c). Finally, the most English-like contrast (4c) is most likely indicative of an English-dominant unbalanced bilingual. This kind of imposition of structure (cf. Natvig 2019; van Coetsem 1988), would result in active phonological behavior involving aspiration and not voicing, a clear difference from the Spanish phonological system and its processes. Production patterns that align with these representations encourage additional methods to investigate whether the Spanish GT dimension is present or merely not accessed in speech (see related discussion in (Miller and Rothman 2020)).

(4) Potential differentiations of structure for Voicing and Aspirating systems





Any set of contrasts a Heritage Spanish speaker may use that indicates *phonological* evidence for a /b d g/ specification, i.e., (4a,4b), is consistent with the acquisition and maintenance of the Spanish phonological system because GT is not generalizable from English input alone. Whether or not contact with English induces real-time changes to the lead VOT in Spanish /b d g/ or lag VOT in /p t k/ (e.g., Kim 2011), sheds light on the procedural behavior reflected in PHONETIC or PHONETIC-PHONOLOGICAL patterns. Therefore, it is only the situation represented in (4c) that indicates the use of PHONOLOGICAL representations that do not follow the expected Spanish system. In this contrastive subset, all the phonological work occurs within the English feature system, regardless of whether a speaker acquired only those representations or they only access them (see Section 5). Whether a particular speaker, or group of speakers, adopts and implements any of the contrastive subsets of the integrated system presented in (4) depends on a host of factors, such as language mode, social context and register, age and sequence of MajL acquisition, degree of use and access of representations, and general language development over the lifespan.

To illustrate potential asymmetries across sound system modules, Table 3 schematizes the levels of representations for the potential HL Spanish structures outlined in (4). Beginning with (4a), the most distinct from English, aspiration may still enter into the system as an enhancement (+[spread]) of the unspecified /p t k/ series. In such a scenario, long-lag VOT is likely to be highly variable and irrelevant for any phonologically active patterns. The hybrid representations of (4b) predicts that speakers implement both GT and the English dimension GW as active features in Spanish. With an integrated set of contrasts like in (3), such a preference for phonological features is understood as an outcome from speakers accessing a subset of available representations, not from a fundamental difference in the architecture of heritage language grammars. Finally, the most English-like architecture of (4c) marks the opposite extreme from (4a), where only GW is active in phonological patterns, although there may be indications of PHONETIC-level voicing due to +[slack] enhancement.

Table 3. Potential integrated representations and their completions.

| | (4a) Voicing | | (4b) Hybrid | | (4c) Aspirating | |
|-----------|---------------|--------------------------------------|---------------|------------------|-----------------------------------|------------------|
| PHONOLOGY | GT | ∅ | GT | GW | ∅ | GW |
| PHON-PHON | [slack] | (+[spread]) | [slack] | [spread] | (+[slack]) | [spread] |
| PHONETICS | <i>voiced</i> | <i>plain</i> (<i>aspirated</i>) | <i>voiced</i> | <i>aspirated</i> | <i>plain</i> (<i>voiced</i>) | <i>aspirated</i> |

In addition to modeling asymmetric distinctions between gradient patterns of on-line speech productions and abstract representations (Purnell 2009), this integrated architecture provides a framework for comparing domains of overlap and differentiation in HL grammars. The PHONOLOGY consists of shared, hybrid representations, whereas the PHONETICS-PHONOLOGY and the PHONETICS are more prone to varying degrees of differentiation. A hypothetical bilingual speaker who performs ‘monolingually’ in each language completes the relevant phonological categories with the exact same gestures and implements those gestures within the same range of continuous phonetic properties as so-called monolinguals. Yet, sociophonetic variation tends to occur along non-contrastive dimensions (Sonderegger et al. 2020), and phonetic implementation may be highly variable (see Natvig and Salmons 2021, on how this model fits with variationist sociolinguistics). Therefore, PHONETICS-PHONOLOGY and PHONETICS are regionally, socially, and contextually differentiated, which captures the “multiple overlapping rule systems acquired through our participation in divergent speech communities” (MacSwan 2017, p. 179) that underlies the universal multilingualism perspective. It is accordingly HL-speakers’ experiences within their speech communities—a set of social situations that often undergoes dramatic changes over the course of their lifetimes—that influence the degree to which they manipulate phonemic categories in such a way that they align with patterns for comparison groups.

To summarize this model, there are at least three distinct levels of representation: PHONOLOGY represents contrasts, PHONETICS-PHONOLOGY builds articulations/gestures from abstract categories, and PHONETICS is the properties of the speech signal. A multilingual sound system, I argue, consists of *all* contrastive representations, both shared and unique to each language, that comprise speakers’ integrated grammatical knowledge. These categories can undergo various completion and implementation procedures depending on language mode and social context, representing speakers’ procedural behavior. Because phonology is underspecified relative to the phonetics, and because an integrated phonology will be a superset of the contrasts required for any individual language, there will be a host of asymmetries and ambiguities across modules. The model of an integrated multilingual sound system adheres to these principles and characteristics:

- The sound system is modular and consists of at least the PHONOLOGICAL, PHONETIC-PHONOLOGICAL, and PHONETIC levels of representation.
- PHONOLOGICAL: Contrastive features are a shared set of abstract dimensions that divide a phonemic inventory following the Successive Division Algorithm. The representations necessary for one language may be a subset of the integrated system. These representations are furthermore underspecified relative to surface forms.
- PHONETIC-PHONOLOGICAL: Underspecified, contrastive representations are completed and/or enhanced with articulatory gestures. These processes may be shared or differentiated based on language, sociolect, register, etc.
- PHONETIC: Articulatory gestures are implemented in real time. These processes may be highly variable and plastic.
- Speakers may have varying degrees of shared and differentiated operations at the PHONETIC-PHONOLOGICAL and PHONETIC levels of representation based on experience with and in the particular languages in question.

In the next section, I survey some ways in which these modular relationships unfold in HL contexts.

4. Case Studies

In this section, I review a selection of studies on HL laryngeal patterns using an integrated multilingual phonology from the shared representations in (3). For each, I provide a brief justification for the shared sets of contrasts based on expected inventories, assuming full acquisition/attainment of the contacting languages’ distinctive features. Each subsection highlights phonetic-phonological ambiguities along different parameters. In Section 4.1, I consider West Frisian and English phonetic patterns that are ambiguous with respect to the kind of phonological system they correspond to (i.e., Voicing or Aspirating) when each is possible from the respective systems (Ehresmann and Bousquette 2021). In the next Section 4.2, I discuss ambiguous outcomes of similar phonological processes, final laryngeal neutralization, in Toronto Polish and the local English (Łyskawa et al. 2016). Finally, in Section 4.3, I review asymmetric laryngeal patterns of Western Armenian, a HL spoken in Lebanon and in the US and in contact with Voicing (Arabic) and Aspirating (English) languages (Kelly and Keshishian 2021). The goal of this survey is to demonstrate the value of the integrated multilingual sound system for analysing HL sound systems, and to discuss limitations on what we can determine about HL phonology based largely on surface-level phonetics.

4.1. Ambiguous Surface Patterns: Wisconsin Frisian

As an example of the often ambiguous correlation between surface forms of discrete representations, consider nascent work on the laryngeal acoustics of the moribund (West) Frisian HL spoken in Randolph, WI, i.e., Wisconsin Frisian (Bousquette and Ehresmann 2010). Frisian—along with Dutch and Yiddish—is among the few Germanic languages with a Voicing system, where we otherwise find Aspirating systems (Salmons 2020, p. 134). Yet Ehresmann and Bousquette (2021) find fully voiced and aspirated stops in the HL, with speakers implementing the contrast using both lead VOT and long-lag VOT.⁵ These surface forms are undoubtedly products of Frisian-English HL bilingualism, however they raise the question as to what extent voicing and aspiration correlate to the specified, contrastive dimensions in an integrated Frisian-English phonology. Recall from Table 3 that there is a great deal of potential overlap and ambiguity in the surface phonetics and phonological representations, such that all the representation types in (4) can capture these surface distributions. These contrastive subsets express interrelated phonological and phonetic outcomes, all of which *may* present with voiced and aspirated surface contrasts.

Further investigation into whether GT, GW, or both are active in phonological processes will provide evidence for distinguishing between competing phonological structures (summarized in Table 4), and for arriving at an understanding of the phonological outcomes of Frisian-English HL bilingualism in Wisconsin. Does Wisconsin Frisian behave like (i) a Voicing language (4a), (ii) an Aspirating language (4c), or (iii) a hybrid system (4b), with both dimensions available for phonological computations? If patterns are consistent with an Aspirating system, i.e., a GW-∅ contrast, can evidence of a GT category be uncovered to distinguish between an integrated Frisian-English phonology and one based solely on English representations? Although some of these questions may remain unresolved due to the unique characteristics shared by many elderly speakers of moribund HLs, examining the distribution of these features, how they compare across languages, speakers, and contexts, will go a long way in triangulating the qualities of the HL phonological grammars (for discussion, see D’Alessandro et al. 2021).

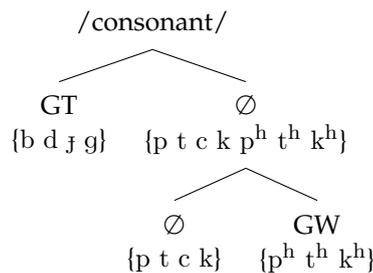
Table 4. Potential Frisian-English representations, with completions and activity for Frisian.

| | (4a) Voicing | | (4b) Hybrid | | (4c) Aspirating | |
|-----------|---------------|------------------|---------------|------------------|-----------------|------------------|
| PHONOLOGY | GT | ∅ | GT | GW | ∅ | GW |
| PHON-PHON | [slack] | + [spread] | [slack] | [spread] | + [slack] | [spread] |
| PHONETICS | <i>voiced</i> | <i>aspirated</i> | <i>voiced</i> | <i>aspirated</i> | <i>voiced</i> | <i>aspirated</i> |
| ACTIVITY | Active | Inert | Active | Active | Inert | Active |

4.2. Ambiguous Phonological Processes: Toronto Polish Devoicing

Like Wisconsin Frisian, Toronto Polish is a HL where the baseline has different laryngeal representations than the MajL (Łyskawa et al. 2016). What is particularly valuable with this study is that they investigate a phonological process, final devoicing, and the extent to which this rule is present for Toronto Polish HSs. This type of study offers evidence for whether their grammars contain requisite phonological features in the phonology and whether speakers maintain core phonological processes. The integrated system of Toronto Polish and English comprises Voicing and Aspirating representations, as in (3), adapted for Polish in the contrastive hierarchy in (5).

(5) Integrated Polish-English laryngeal representations



For Polish, voiced obstruents undergo a neutralization process and devoice word finally (Iverson and Salmons 2011; Łyskawa et al. 2016). This operation does not occur before voiced obstruents, likely due to regressive spreading of GT from the onset of the following word. Irrespective of the environment in which it occurs, devoicing in Polish—as well as Dutch, Catalan, etc.—involves a contextually conditioned deletion of the GT from members of the the voiced series. In contrast, final devoicing (or *final fortition*) in languages with Aspirating systems like German consist of the introduction of a [spread] gesture on the unmarked series (/p t k/), rendering them phonologically aspirated (Iverson and Salmons 2011). We can consider this a conditioned enhancement (Natvig 2020), where unspecified obstruents are enhanced with +[spread] at some prosodic boundary (syllables, words, etc.). The result is a surface-level neutralization of the phonological contrast. Crucially, final devoicing and final fortition are two different processes that occur at different levels of representation, and that target different phonemes. The former is the PHONOLOGICAL removal of the GT dimension for /b d ʃ g/ in Polish and the latter is the PHONETIC-PHONOLOGICAL insertion of the [spread] gesture for the unspecified /p t k/ class in German, as well as Toronto English (Smith 2013). A comparison of these processes is illustrated in Table 5.

Table 5. Comparison of devoicing and fortition.

| | Devoicing | | Fortition | |
|-----------|------------------|------------------|------------------|------------------|
| PHONOLOGY | GT | ∅ | ∅ | GW |
| PHON-PHON | | | + [spread] | [spread] |
| PHONETICS | <i>voiceless</i> | <i>voiceless</i> | <i>aspirated</i> | <i>aspirated</i> |

By comparing two generations of Toronto Polish HSs (Gen1, Gen2) with homeland Polish and Toronto English speakers, Łyskawa et al. (2016) examine the extent to which HSs devoice Polish word-final stops, and whether there is any interaction between the Polish and English laryngeal neutralization processes. I consider here two of their findings:

1. Toronto Polish speakers implemented the devoicing rule at a higher rate than the homeland group (Homeland: 66%, Gen1: 67%, Gen2: 74%), and
2. Gen2 devoiced less before voiceless obstruents than Gen1 and homeland speakers.

A key point for understanding these contact patterns is that in an integrated phonology of the type in (5), where both devoicing and fortition may occur, the application of

both processes in Table 5 will not result in a higher incidence of devoicing for a single series. Rather, the application of both rules would increase the likelihood that the devoiced obstruents will be aspirated because the fortition process targets the phonologically unspecified, not the phonologically voiced, phonemes. Furthermore, the decrease in devoicing before voiceless obstruents for Gen2 cannot be the result of English influence; not because of the overall rates of rule application (*pace* Łyskawa et al. 2016), but because the English process would apply to an already voiceless (=devoiced) stop in Polish. The uptick in the general application of the devoicing rule, as well as a decrease in an isolated phonological environment, is an outcome consistent with other studies on HL sound systems that find differences in the distributions of existing forms and patterns (Kupisch 2020). Here, we find a change in procedural behavior in implementing an already present process. The comparably high rates of Polish devoicing across all three groups is consistent with cross-generational acquisition of Polish phonology and its rules. Because these HSs have strategies for neutralizing both Voicing (Polish) and Aspirating (Toronto English) contrasts, they can apply those computations within a range that is the same as, or close to, the expected Polish pattern. Whether or not the *representations* are consistent across all groups, and among speakers within each group, additionally requires an acoustic examination of both classes of stops and an analysis of the behavior of the voiced series when laryngeal distinctions are not neutralized.

In addition to finding clear evidence of HSs’ competence and complex sound patterns of both languages, Łyskawa et al.’s (2016) investigation is extremely valuable for highlighting distinctions between rules, representations, and their interactions in investigating HL and other bilingual grammars. Although phonological computations provide evidence of active processes, under certain conditions their outcomes may not in and of themselves distinguish between competing contrastive subsets. In such cases, it is necessary to investigate potential changes in representations, in addition to how speakers produce them in speech, in order to assess the phonological stability or vulnerability for a given HL-speaking population.

4.3. *Asymmetric Outcomes across Dyads: Western Armenian*

A critical component for furthering our understanding of the underlying structures and characteristics of heritage languages is through examination of patterns in a variety of contact scenarios, or dyads (Scontras and Putnam 2020). Kelly and Keshishian (2021) make an important contribution with their investigation of Western Armenian (WA) laryngeal features in two bilingual settings: for HSs with (i) Arabic and (ii) English as the MajL. They find surface patterns that clearly align with the MajL phonological systems: Voicing for Arabic and Aspirating for English (Kelly and Keshishian 2021). Yet, the extent to which the contrastive representations of the WA has undergone changes in one or either setting remains unclear based on phonetics alone.

One factor that contributes to this ambiguity is that, similar to Wisconsin Frisian, WA surface patterns may correspond to multiple underlying representations. Because WA expresses a two-way laryngeal contrast through voicing and aspiration (Baronian 2017; Kelly and Keshishian 2021), they may be the implementations of a Voicing system (2a) with +[spread] enhancement, an Aspirating system (2b) with +[slack] enhancement, or a hybrid system like (3) that is indicative of an integrated phonology representing Voicing and Aspirating systems and the implementation of the GT-GW subset.⁶ A comparison of these systems is presented in Table 6.

Table 6. Potential Western Armenian laryngeal representations and their completions.

| | (2a) Voicing | | (2b) Aspirating | | (3) Hybrid | | |
|-----------|---------------|------------------|-----------------|------------------|---------------|------------------|---|
| PHONOLOGY | GT | ∅ | ∅ | GW | GT | GW | ∅ |
| PHON-PHON | [slack] | + [spread] | + [slack] | [spread] | + [slack] | [spread] | — |
| PHONETICS | <i>voiced</i> | <i>aspirated</i> | <i>voiced</i> | <i>aspirated</i> | <i>voiced</i> | <i>aspirated</i> | — |

Kelly and Keshishian (2021) show that when one of these underlying systems is in contact with Arabic in Lebanon, speakers implement the contrast as voiced [b d g] and voiceless [p t k]; in the US, however, speakers have aspirated [p^h t^h k^h] and vary between fully voiced [b d g] and plain [p t k]. It is undeniable that HL bilingualism influences the phonetic patterns of WA stops to align more closely to the MajL (Kelly and Keshishian 2021). Based on the three potential contrastive representations for a phonetically overmarked voiced-aspirated distinction outlined in Table 6, different interpretations of the outcomes in the separate contact settings follow. The implications for WA phonetic/phonological change embedded in Arabic and English dyads, starting from the distinct representational structures, are:

- WA Voicing system (2a):
 - WA undergoes no PHONOLOGICAL change in contact with Arabic, but there is a loss of +[spread] enhancement (PHONETIC-PHONOLOGICAL change);
 - WA and English are integrated into a Voicing-Aspirating system, with variable implementation of the English contrast (i.e., plain stops) or PHONOLOGICAL change to Aspirating system, with variable +[slack] enhancement (a PHONOLOGICAL dimension changes to a PHONETIC-PHONOLOGICAL gesture);
- WA Aspirating system (2b):
 - Results show either an integrated WA-Arabic laryngeal system, with implementation of the GT-∅ subsystem in WA, or complete PHONOLOGICAL change to the Arabic Voicing system;
 - No PHONOLOGICAL change in contact with English; instead patterns show (variable) reduction of +[slack] enhancement (PHONETIC-PHONOLOGICAL change);
- WA Overmarked (integrated) system (3):
 - Patterns in neither dyad distinguish between abstract representations or potential structural change. Rather, they demonstrate settings in which the implementations of contrastive subsets are modulated by MajL: Type (4a) for Arabic and type (4b) and/or type (4c) for English.

These patterns underscore divergent outcomes that result from pressures that different contacting representations place on HL speech patterns. The processes underlying these changes require further investigation into the MajL's influence on the contrastive representations and the phonological operations that manipulate them in the HL.

In this section, I presented three studies in HL sound patterns that neatly illustrate asymmetries between sociophonetic distributions and their corresponding representational structures. These asymmetries in turn push us to ask deep questions about the nature of HSs' phonological grammars. Because the use of available representations for HSs, and bi/multilinguals in general, is likely to be dynamic (Pliatsikas 2020), the implementations of those categories are likewise prone to varying degrees of differentiation. Since variation and change for HSs should be subject to the same underlying mechanisms as monolinguals, and because the particular sociolinguistic contexts that HSs find themselves often vary greatly from those of majority language speakers, we should expect their surface forms to reflect those differences. In addition to phonetic properties, an analysis of the phonological grammar of a HL requires an investigation of the contrastive properties of the sound systems' inventories and phonological behaviors with respect to the distinctive features of the integrated phonology. Sociophonetic distributions—and even some types of phonological rules—will provide evidence for how speakers produce representations, but not necessarily for what those representations must be nor how they may change within, among, or across speakers over time. This is critical context for understanding broader concerns in HL phonetics and phonology, particularly regarding questions of variation, change, and development over the lifespan. In the following section, I elaborate on the implications of adopting universal multilingualism for interpreting those issues.

5. Discussion: Contextualizing Heritage Language Effects

This integrated multilingual model is a phonological approach to universal multilingualism that captures asymmetries between discrete, abstract phonological representations and their gradient, concrete phonetic patterns. These asymmetries very often result in ambiguous relationships between levels of representation. Assuming an underspecified phonology, there is a one-to-many correspondence between the features of the PHONOLOGICAL and PHONETIC modules. An integrated phonological system that represents *all* relevant phonemic contrasts—irrespective of their language of origin—also models potential many-to-one PHONOLOGY-PHONETICS correlations. Specifically, a given set of surface-forms, e.g., voiced obstruents, may result from the completion and implementation of a specified dimension (GT) or via enhancement of an unspecified \emptyset class of phonemes, here with +[slack]. Although this framework assumes a degree of arbitrariness between surface form and phonemic category, it is precisely these types of structural asymmetries that capture gradience in HL phonological representations over time (Celata 2019) as a consequence of changing behavioral routines in accessing those representations across the lifespan (Putnam et al. 2019; Putnam and Sánchez 2013).

The HL phonological grammar is generally held to be fairly stable, even if HSs are often regarded as speaking with an accent in their HL (Benmamoun et al. 2013; Polinsky 2018; Polinsky and Scontras 2020). HSs very often differ from both monolinguals and L2 speakers in their speech production (see Kupisch 2020, for an overview), supporting the observation that HSs are a unique group, with neither L1 nor L2 sufficiently describing their language patterns (Chang and Yao 2016; Putnam et al. 2018). Furthermore, the high rates of inter-individual and intra-individual variation associated with HSs indicate a great deal of heterogeneity in HL sound system with respect to grammatical knowledge and procedural behavior. Polinsky and Scontras (2020) summarize three major causes discussed in the literature for why HSs differ from baseline comparison groups: (i) transfer, (ii) attrition, and (iii) divergent attainment. I contextualize these issues in light of an integrated multilingual sound system and discuss broader implications for phonological theory.

5.1. Transfer

For Polinsky and Scontras (2020), transfer is the use features from the MajL in the HL. Typically, transfer is understood to occur when a particular feature is active in both languages, so support comes from the examination of both (or all) languages (Polinsky and Scontras 2020, p. 5). With respect to an integrated set of contrasts, transfer results from the activation in the HL of a contrastive subset shared with the MajL, in part or in whole. Referring back to the potential differentiations of an integrated Voicing and Aspirating system in (3), all possible ways to mark a two-way contrast in the HL will have at least one shared class with the MajL (cf. 4). For a Wisconsin Frisian speaker, for example, accessing the baseline-like Frisian Voicing contrast, as in (4a) indicates the activation of the shared, unmarked category that also specifies the English plain obstruents (/p t k/). The same situation holds for the other potential subsets that can mark the two-way contrast (4b,4c). The differences lie in the extent of the overlap—one or both natural classes—and in which dimensions are accessed for the implementation of the relevant contrast. HS behavior in this regard will certainly shape surface forms and their phonetic distributions. However, acoustic patterns alone often cannot distinguish between different types of transfer, in terms of both feature subsets and levels of representation (see Table 4).

The modular nature of this integrated architecture likewise predicts multiple types of potential sound system transfer, particularly regarding the procedures that render abstract phonemic categories pronounceable. HSs may, for example, adopt a new enhancement form articulatory gestures available in the MajL, but not previously in HL, and the implementation of gestures in one language may drift toward or away those in another (Chang 2019b; Polinsky 2018). These are PHONETIC-PHONOLOGICAL and PHONETIC effects in this model. As discussed for the asymmetries in Section 4, there are multiple reasons for which these more concrete forms may change without necessarily uprooting the representational

system—although they may precipitate phonological change (de Leeuw 2019). A detailed account of the phonological behavior associated with features in both languages is required to assess cases of phonological transfer, including the comparative degree of differentiation between the two systems, i.e., which contrastive subsets are employed for which language, and how those dimensions are completed and implemented. From such an investigation, one can further infer where in the HL system influences from the MajL occur. The observation that HSs perform asymmetrically along different aspects phonology, e.g., that HSs tend to perceive and discriminate the relevant HL contrasts even if they are not perceived as L1 speakers (Kupisch et al. 2014; Oh et al. 2003), supports a clear distinction between (contrastive) representational categories and the surface properties of speech.

5.2. Attrition

Regardless of the extent to which HL representations and processes align with those of the MajL, it is not always clear whether they reflect a fairly stable state for the HL or the reorganization of the relevant (sub)system. The latter condition, ‘attrition’, describes a situation in which a particular structure, feature, pronunciation, etc., in a language is acquired and later lost due to the decreased use of that language (Schmid 2011). As with transfer, the modular domain in which a particular developmental change occurs is critical for understanding its broader impact on HL phonology. Specifically, if there is longitudinal evidence for a loss of a particular sound, is there a concomitant loss of the corresponding contrastive representation? Whatever differences are present in the speech sounds of HSs compared to some baseline group, PHONOLOGICAL attrition implies the loss an abstract contrast. However, whether a contrast is lost, or not activated, is largely ambiguous from production data.

Consider, for instance, the WA-English dyad in Section 4.3, with an integrated laryngeal system like (3). This system is based on Kelly and Keshishian’s (2021) arguments for a GT-GW subset that would be integrated with English GW-Ø. Assuming here that the group that produces the contrast with short-lag VOT /p t k/ and long-lag VOT /p^h t^h k^h/ uses the English-like GW-Ø contrastive subset in (4c), there is superficial evidence of the loss of the GT dimension. The question of whether or not that GT category exists and speakers can access it, however, is another matter, and one that must be addressed with complementary online and offline methods (Miller and Rothman 2020). It is, for example, possible that attrition-like patterns in HL phonology are the result of speakers’ difficulties in inhibiting the activation of the MajL representations in speech production (Putnam et al. 2019; Putnam and Sánchez 2013), but that they still may be accessible for categorical discrimination, which tends to be stable even under limited input and exposure (Celata 2019; Flores and Rauber 2011; Hyltenstam et al. 2009). Such a situation is consistent with the ‘robust’ nature of HL phonology (Polinsky and Scontras 2020) if the PHONOLOGY, as argued here, consists only of contrastive substance. Shifts in the procedures that convert those representations into speech—whether through incidental transfer or from a systematic increase over time toward the MajL—support the present model’s predictions that the PHONETIC and PHONETIC-PHONOLOGICAL modules are more susceptible to MajL influences than PHONOLOGICAL contrasts are (Natvig 2019). This modular design captures the ways in which HSs *do* differ from other groups (Kupisch 2020; Kupisch et al. 2014), even with a fairly stable system of phonological representations.

In addition to modeling asymmetries in HSs’ phonological behavior, a further benefit to a contrast-based, modular sound system is that it accounts for representational gradience in a (semi)substantive framework. There is considerable congruence here with exemplar and construction-theoretic approaches, where experience-based memorization derives representational content (e.g., Bybee 2001). These frameworks are argued to accommodate the gradient nature of temporal phonological developments:

Changes in category location and number are therefore expressions of essentially temporal developments in the process of updating this abstract knowledge from continuously varying input episodes. However, including time in phonology es-

entially makes phonology continuous, much like phonetics, rather than categorical, in contrast with much thought in phonological research (Celata 2019, p. 219).

The feedback that speakers/listeners receive, including the extent to which those experiences are distributed across distinct language modes, informs both how they access various contrastive subsets in a fully integrated system of discrete representations as well as the PHONETIC-PHONOLOGICAL and PHONETIC procedures that modulate their characteristics in the speech signal. Following from the integrated multilingual sound system, categories can exist as contrasts or not; this is however distinct from whether or not speakers act upon particular features in speech and in comprehension. Uncovering the nature of PHONOLOGICAL attrition requires understanding the conditions where an inability to inhibit MajL representational structures restricts speaker access to that MajL contrastive subset and no more. A focus on the composition of representations based on surface-level properties reveals how speakers realize their phonological knowledge in context, and how those behaviors strengthen some speech patterns, while diminishing others. These are the same sociolinguistic mechanisms that govern the structured heterogeneity of phonetic and phonological variation (Natvig and Salmons 2021).

5.3. Divergent Attainment

Finally, it is often difficult to determine whether these or any changes are transfer effects, the results of developments over the lifespan, or instead the outcomes of different acquisition trajectories, which (Polinsky and Scontras 2020, p. 5) refer to as “divergent attainment.” Because it refers to differences in the grammar, I consider divergent attainment to pertain to the grammatical knowledge encoded in the PHONOLOGY, rather than PHONETIC or PHONETIC-PHONOLOGICAL procedures. As discussed in Section 4, HSs may vary substantially from baseline comparison groups in their acoustic properties without this necessarily correlating with different sets of contrastive features. Therefore, the potential divergent attainment of the phonology must be evaluated in terms of phonological behavior and feature activity. Consider again the integrated Wisconsin Frisian-English representations in (6), where (6a) represents a hypothetical generation (GEN_X) that acquired the Frisian Voicing and English Aspirating systems and (6b) shows a hypothetical subsequent generation (GEN_{X+1}) without a GT specification for voiced obstruents, or ‘divergent attainment’ of the Frisian system. Table 7 illustrates possible completions, enhancements, and feature activity of the Wisconsin Frisian laryngeal contrasts in each generation.

(6) Example of cross-generational divergent attainment of laryngeal contrasts

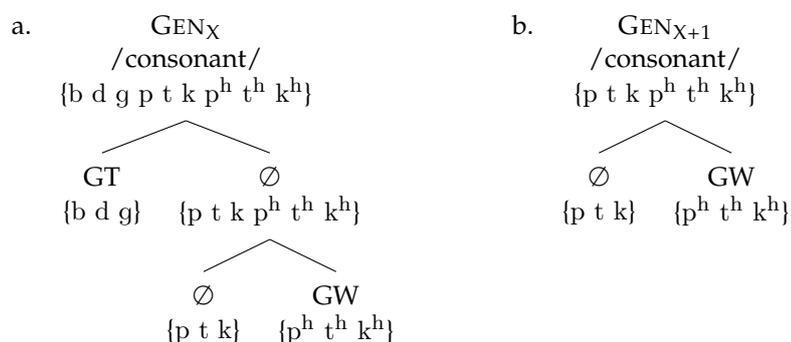


Table 7. Comparison of cross-generational laryngeal representations.

| (6a) GEN_X Voicing | | | | |
|--|------------------|------------------|---------------|------------------|
| PHONOLOGY | GT | ∅ | GT | ∅ |
| PHON-PHON | [slack] | | [slack] | +[spread] |
| PHONETICS | <i>voiced</i> | <i>voiceless</i> | <i>voiced</i> | <i>aspirated</i> |
| ACTIVITY | Active | Inert | Active | Inert |
| (6b) GEN_{X+1} Aspirating | | | | |
| PHONOLOGY | ∅ | GW | ∅ | GW |
| PHON-PHON | | [spread] | +[slack] | [spread] |
| PHONETICS | <i>voiceless</i> | <i>aspirated</i> | <i>voiced</i> | <i>aspirated</i> |
| ACTIVITY | Inert | Active | Inert | Active |

In a comparison of Frisian contrasts for both GEN_X and GEN_{X+1}, the surface forms on the left in Table 7 are the same as their respective phonological features, with phonetic patterns that directly reflect a cross-generational change in underlying representations. However, those to the right have one form-representation mismatch due to enhancements. In a situation in which both generations enhance the contrast through either aspiration or voicing, the voiced and aspirated phones correspond to different contrastive representations. In this scenario, GEN_{X+1} generalizes different abstract representations than GEN_X, although with no difference in their surface realizations (cf. Ohala 1981, 1993), a type of phonological change (Blevins 2004, p. 32) calls CHANCE:

The phonetic signal is accurately perceived by the listener but is intrinsically phonologically ambiguous, and the listener associates a phonological form with the utterance which differs from the phonological form in the speaker’s grammar.

The divergent attainment of the phonological system in this example is phonetically covert. Evidence for cross-generational differences in grammatical knowledge will ideally come from comparing patterns of phonological behavior and phonemic discrimination routines, and triangulating those results with variable distributions of speakers’ phonetic variation, in both (or all) languages. Even with clear evidence for different grammatical properties, the mechanisms that result in different outcomes of acquisition for HSs are no different than the processes that underlie language change for (assumed) monolingual populations. Language acquirers encode a representational system based on heterogeneous and variable linguistic input (Salmons 2021; Weinreich et al. 1968), it just so happens that for HSs, that input may often be markedly different in both quality and quantity than it is for monolinguals (Pascual y Cabo and Rothman 2012; Putnam et al. 2018).

Examining transfer, attrition, and divergent attainment with integrated phonological representations and a modular architecture illuminates some paradoxes of robust yet vulnerable HL sound systems (Benmamoun et al. 2013; Kupisch 2020; Kupisch et al. 2014; Polinsky and Scontras 2020). First, grammatical knowledge is distinct from procedural behavior, such that PHONOLOGY, the domain of contrastive representations, is comparatively stable. Even if HL phonetics differs from baseline comparisons and its correspondence to abstract representations is ambiguous, HSs tend to be able to access those representations in perception tasks (Flores and Rauber 2011; Hyltenstam et al. 2009). Second, the procedural behavior expressed in the PHONETICS-PHONOLOGY and the PHONETICS are more sensitive to the specific properties of speech sounds, which may vary quite widely given the heterogeneous nature of HL acquisition and use over the lifespan (Pascual y Cabo and Rothman 2012; Putnam et al. 2018). As with monolinguals, these modules are furthermore subject to socially motivated changes in context and over time (Natvig and Salmons 2021). In sum, PHONETIC and PHONETIC-PHONOLOGICAL plasticity reveals how speakers respond to sociolinguistic norms, interactions, and feedback, etc. (Nodari et al. 2019), not necessarily in the abstract contrasts that those sounds express.

6. Conclusions

The dualism of HL sound systems offers unique opportunities for developing and testing formal models, with implications for approaches to acquisition, language variation, and language change. I have argued that an accurate understanding of HL sound patterns comes from first considering all representations in an integrated system, and in distinguishing the grammatical knowledge of contrasts from the procedural behavior of how those contrasts are produced in speech. The integrated multilingual sound system captures perception-production asymmetries, loci of plasticity and variability within a potentially stable overarching system, and contextualizes outcomes from transfer, attrition, and divergent attainment as more universal linguistic processes, albeit under the backdrop of potentially unique social settings for heritage language speakers.

The goal of this article was to clarify some formal underpinnings of processes that affect HL sound patterns. However, the need to explicitly adopt universal multilingualism as the default condition in phonological theorizing cannot be overstated. Considerable work remains in testing this model in other phonological domains, both for segmental and suprasegmental structures, and to fully develop a more nuanced account of structural relationships and linguistic outcomes. Research along these lines stands to benefit both work in heritage languages and formal approaches to language. Parallel advances toward a fuller understanding of the structural, cognitive, and social influences on speech sounds will no doubt be mutually beneficial and supportive. Recently, Chang has called for methodological approaches to fully embrace a multilingual model and “examine these multilinguals as multilinguals” (Chang 2019a, p. 110). I have outlined here a concrete step toward that objective for formal theorizing in phonology by presenting a model that captures the tensions between shared and differentiated representations and behaviors.

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Notes

- ¹ I refer to voiceless stops/obstruents as those that contrast with voiced ones and plain as those that contrast with aspirated ones. In a system where both voiced and aspirated classes are specified, voiceless and plain are synonymous with respect to the phonology.
- ² See Purnell and Raimy (2015) and Natvig (2020) for a complete feature geometry of dimensions and their potential completions.
- ³ Kwon (2021) takes a similar approach to the developmental path of L2 contrast acquisition.
- ⁴ There are many other paths to acquiring representations for the GT, GW, and \emptyset classes. These may indeed turn out to be relevant factors for fine-grained differences in HSS’ production and comprehension of sound patterns. Here I only comment on differences in representation types (i.e., contrastive features, enhancements, timing, etc.), not all the permutations for how features may relate to each other in an integrated system.
- ⁵ Vanhecke and Hietpas (2021) likewise find ambiguity in cross-generational laryngeal patterns of Wisconsin Dutch speakers, another instance of contact in different laryngeal systems (Salmons 2020).

- ⁶ Such a system would suggest that WA phonology is already a subset of an integrated, multilingual system. Its status as a language spoken in a Turkish diaspora (Kelly and Keshishian 2021) may be consistent with this, although research into this specific question is necessary.

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