Getting your Gutturals out of the Mind: An Assessment of the Role of Phonology in the Patterns of Historical Gutturals in Modern Hebrew

Ignacio L. Montoya

1 Introduction

In traditional accounts of the morphology of Hebrew, the primary basis of word formation is an underlying consonantal root and a vocalic/prosodic template. The root conveys semantic information (e.g., the root /g-d-l/ corresponds roughly to "growth" or "largeness," as in *gadal* 'he grew', *gidlu* 'they raised', *lehagdil* 'to enlarge', *gadol* 'big', *godel* 'size', and *migdal* 'tower'). In verbal conjugations, the consonantal root combines with a vocalic/prosodic template that carries inflectional and derivational information (e.g., $C_1o'C_2eC_3$, corresponds to PRES.SG.MASC in the *pa'al* conjugation class, as in *go.ˈdel* 'he grows').

Though they are recognizably members of the same verbal paradigm, some words deviate from the canonical form with regard to syllable structure, the number of surface root consonants, and the number and quality of vowels in the template. For instance, in the PRES.SG.MASC of *pa'al*, the canonical form is an open syllable followed by a stressed closed syllable, forming an iambic foot: CV.ˈCVC. Some words in this conjugation class, however, exhibit different syllable structures: *go.ˈel* 'he redeems' (CV.ˈVC), *mo.ˈtse* 'he finds' (CV.ˈCV), *ʃo.ˈme.a* 'he hears' (CV.ˈCV.V), and *ʃo.ˈle.aχ* 'he sends' (CV.ˈCV.V͡C). In addition, all but one of these words seem to have fewer than three surface consonants, and two of them also contain an additional *a* in the vocalic pattern. The deviation in the vocalic pattern can be seen more markedly in the future tenses of this conjugation class (e.g., canonical *tigdeˈli* 'you (fem.) will grow' versus exceptional *taamˈdi* 'you (fem.) will stand'). The minimal triplet *koˈʁet* 'she reads', *koʁˈaat* 'she tears', *koˈʁa* 'it (fem.) happens' (cf. canonical *koˈʁ͡etset* 'she winks') further illustrates the exceptional nature of certain words.

This paper seeks to explain the behavior of these exceptional words. The orthography indicates that they all historically contained gutturals (*ʔ, h, ʕ* and *ħ*), which suggests that the exceptional words can be explained via phonological approaches, as has been proposed by the few accounts that have dealt with them. Two early generative treatments posit underlying abstract elements to account for the behavior of these words (Bar-Lev 1977, Bolozky 1978). A more recent account that uses the analytical tools of Optimality Theory (OT) challenges the abstractness of these earlier accounts (Faust 2005). The present paper begins by expanding on both the generative and OT treatments by proposing a wider array of ordered rules and ranked constraints than is found in previous accounts. Using an Evolutionary Phonology (EP) framework, the paper then addresses some of the shortcomings of those treatments, including the abstractness of the generative account and the difficulty with opacity in the OT account. In EP, explanations for sound patterns can come from a variety of sources and pure phonology is what remains after extra-phonological factors are extracted (Blevins 2004:21). In addition to phonological considerations, other explanatory tools that will be marshaled to account for the Modern Hebrew patterns with gutturals include phonetically motivated sound change, external factors such as language contact and prescriptive norms, and analogy.

2 Modern Hebrew Background

The linguistic history of Hebrew, a Semitic language of the Afroasiatic family, is unique among the world's languages. There is not a continuous line of native speakers connecting the language spoken during Biblical times (Biblical Hebrew) and that spoken in present-day Israel (Modern Hebrew), which was revived as a spoken language starting in the nineteenth century by immigrants to Palestine from throughout the world (Sáenz-Badillos 1996).

Though the precise composition of the inventory is one of the issues addressed in this paper, one commonly accepted set of phonemes in Modern Hebrew consists of 5 vowels – *i*, *e*, *a*, *o*, u̲ – and 23 consonants (Table 1) (Laufer 1999). These sounds are represented orthographically in the everyday modern language with 22 letters, which depict primarily consonants.

	bilabial	lab-dent.	alveolar	postalv.	palatal	velar	uvular	glottal
stop	p b		t d			k g		ʔ
nasal	m		n					
fricative		f v	s z	ʃ ʒ			χ ʁ	h
affricate			ts	tʃ dʒ				
approximant					j			
lateral			l					

Table 1: Conventional consonant inventory for Modern Hebrew.

The inventory in Table 1 reflects the pronunciation of the majority variety, General Modern Hebrew, which differs from Sephardic Modern Hebrew in ways relevant to this paper.[1] The former is based on the phonology of speakers whose origins are in Europe; speakers of the latter have origins in the Middle East and North Africa. The early speakers of General Modern Hebrew spoke European languages (primarily Russian, German, and Yiddish); the early speakers of Sephardic Modern Hebrew spoke primarily Arabic as a native language (Pariente 2010). An important difference between the phonemic inventories of the European languages and Arabic is that only the latter include pharyngeal fricatives (*ħ* and *ʕ*). These two pharyngeals are historically attested for Hebrew (Khan 1997); however, in the modern varieties, these sounds are present only in Sephardic Modern Hebrew. New generations of speakers, even those whose parents speak the Sephardic variety, are now speaking only the pharyngeal-less general variety (Pariente 2010).

The pharyngeal fricatives, together with the laryngeals (the glottal fricative *h* and the glottal stop *ʔ*), form a class of sounds known as the *groniyot*, "throaty sounds": the gutturals. Phonetically, the sounds are characterized by a primary constriction between the larynx and the oropharynx (McCarthy 1994). Though only the laryngeals are claimed to be in General Modern Hebrew, all four represent sounds of older forms of Hebrew, a fact that is recorded in the orthographic system: *alef*, א ,is historical *ʔ*; *hei*, ה, is historical *h*; *ayin*, ע, is historical *ʕ*; and *chet*, ח, is historical *ħ* (Khan 1997). In the general modern variety, *alef* and *hei* continue to represent *ʔ* and *h*, respectively; *ayin* has merged with *ʔ*; and *chet* is *χ*, a pronunciation it now shares with *kaf*, כ, the historical voiceless velar stop (Khan 1997).

Hebrew letter	transliteration	Biblical Hebrew	Modern Hebrew
א	*alef*	ʔ	ʔ
ה	*hei*	h	h
ע	*ayin*	ʕ	ʔ
ח	*chet*	ħ	χ

Table 2: Conventional correspondences of gutturals in Biblical Hebrew and Modern Hebrew.

3 Data

Words were selected from a book of verb conjugations and their pronunciations (Bolozky 2008) and then cross-referenced with a second list.[2] To the extent possible, each historical guttural in each of the three root positions was represented. The pronunciations of the selected verbs were checked with two native speakers[3], who also provided their impressions of the nature of any variability they noted (e.g., register differences, generational influences, etc.). To determine more pre-

[1] Unless otherwise specified, the term Modern Hebrew refers to General Modern Hebrew. Sephardic Modern Hebrew (following Pariente 2010) is also sometimes referred to as the Oriental or Eastern variety (e.g., Laufer 1999, Laufer and Baer 1988).

[2] This list was compiled by a mobile app designer at Too Juice Applications who reports using the following sources: Bolozky (2008); Tarmon and Uval (1998).

[3] The informants were a male and female from Jerusalem, both college-educated, around age 30.

cisely the nature of the variability, a sociophonetic study is recommended.

The descriptive tools used to organize the data are from Generative Phonology and OT: ordered rules of the former and ranked constraints of the latter. Though ordered rules and ranked constraints are theoretical entities associated with certain assumptions (e.g., a role in Universal Grammar), they are used here primarily to describe the data; a broader assessment of the theoretical assumptions is touched upon in only a superficial manner. It should be noted that the working assumption involved with using these tools is that the patterns constitute a primarily phonological phenomenon, i.e., one that involves mental representations of sounds and their relationships. This is not an unreasonable premise given that the patterns seem to implicate phonological units such as segments and syllables, and, indeed, three general phonological patterns appear to characterize the data: deletion, vowel epenthesis, and vowel lowering. However, it should be noted that this is merely a working assumption and not an established fact.

3.1 Deletion

As noted above, of the four historical gutturals, only *ʔ* and *h* appear on the surface in Modern Hebrew. These two sounds exhibit similar patterns, which is not surprising given their phonetic and phonological similarity. In terms of distinctive features, *ʔ* and *h* form a natural class, both under a glottal node in feature geometry (Kenstowicz 1994), represented in this paper as [laryngeal].

These two sounds are consistently found only in the formal register (Cohen 2009) (e.g., formal [laʔamod] ‘to stand’ alternates with colloquial [laamod]). The only laryngeal that is consistently produced is *ʔ* at the beginning of a phonological phrase, a phenomenon that is consistent with the commonly occurring laryngeal-closing gesture at a prosodic boundary, as in English (Blevins 2008, Davidson 2012, Garellek 2012).

These patterns support the conventional view of the inventory in which only laryngeals are present in Modern Hebrew. In order to account for the absence of surface laryngeals in colloquial speech, the simplest way to describe these patterns is to view this as a case of deletion and to posit a context-free laryngeal deletion rule, which is optional depending on register:

(1) Laryngeal deletion: [laryngeal] → ∅, laryngeals are deleted in all environments

A second rule, which must be ordered after (1), can then be posited to address the observation that *ʔ* is present at the beginning of a prosodic boundary:

(2) ʔ-insertion: ∅ → ʔ / [__, glottal stop is inserted at the beginning of a prosodic boundary

With regard to OT constraints, we can account for the deletion patterns by positing a highly ranked constraint that disfavors *ʔ* and *h* as segments:

(3) *LAR, laryngeals are not allowed

The presence of *ʔ* in prosodic-initial position can be accounted for by an even higher ranked markedness constraint disfavoring vowels at prosodic boundaries:

(4) *[V, a vowel is not allowed at the beginning of a prosodic boundary

It would be expected to be similar to an ONSET constraint that requires that all syllables have an onset. Alternatively, (4) could instead be written as an ALIGN constraint that requires the left edge of a boundary to be aligned with a consonant. Regardless of the details, a highly ranked constraint is necessary to account for the consistent presence of *ʔ* in a prosodic phrase-initial environment.

With regard to deletion patterns, therefore, both rules and constraints satisfactorily account for the data. Moreover, they support the adoption of the conventional approach to the inventory in which the laryngeals, despite their register-dependent restricted distribution, are phonemes in Modern Hebrew but the pharyngeal are not.

3.2 Vowel Epenthesis

Another general phonological process that emerges from the data can be described as vowel epenthesis, which is characterized by three related patterns. The most common pattern involves epenthesis of a low vowel after an underlying guttural (e.g., /goʔlim/ 'they redeem' → [goʔalim]). A variant of this pattern involves the epenthesis of a mid front vowel in the same environment that occurs only if the preceding vowel is also a mid front vowel (e.g., /niʔsof/ 'they will be gathered' → /neʔsof/ → [neʔesof]). The third pattern is different from the other two in that the epenthesis (of a low vowel) happens before a guttural, though only word-finally (e.g., /soleχ/ 'he sends' → [soleaχ]). Setting aside for the moment the precise identity of the guttural trigger, these three epenthesis processes can be described using three rules:

(5) Post-guttural *a*-epenthesis: ∅ → a / G__C, *a* is inserted between a guttural and a following consonant
(6) Post-guttural *e*-epenthesis: ∅ → e / e ʔ__C, *e* is inserted between following a guttural that precedes a consonant and follows a mid front vowel
(7) Pre-guttural *a*-epenthesis: ∅ → a /__G, *a* is inserted before a word-final guttural

In terms of constraints, what seems to be disfavored in all three cases is a guttural adjacent to another consonant, motivating a constraint against gutturals in consonant cluster:

(8) *GC, a guttural is not allowed adjacent to a consonant

Additionally, since non-high vowels are the epenthetic vowels in all three cases, it is reasonable to assume that high vowels are also disfavored adjacent to gutturals, which, in fact, is supported by data discussed in Section 3.3.

(9) *$V_{[+high]}$ G, a high vowel is not allowed adjacent to a guttural

These two constraints (and an additional one favoring an epenthetic vowel having the same quality as a preceding mid front vowel) motivate the attested repairs involving vowel epenthesis.

Though these rules and constraints, in general, adequately account for the epenthesis patterns, determining the precise identity of the guttural, which varies depending on a number of factors, is problematic. For example, all historical gutturals participate in (5) and (6), but only in the formal register, and, as with deletion, sociolinguistic factors clearly play a role with epenthesis. A more significant issue, though, arises with (7). One distinction that becomes critical in understanding this epenthesis pattern is between *χ* originating from historical *ħ* and *χ* originating from historical *k*; though both are pronounced identically in Modern Hebrew, only the former participates in the epenthesis processes (e.g., [tsoʁeaχ] 'he screams' versus [tsoʁeχ] 'he consumes'). A similar problem arises with *ʔ* originating from historical *ʔ* as opposed to from historical *ʕ*. Only reflexes of the historical pharyngeal fricatives, *ʕ* and *ħ* trigger (7) (cf. the minimal triplet in the Introduction).

One possible solution to this problem is to posit abstractness in the underlying representation. For instance, if the historical pharyngeals have not actually merged but rather remain as phonemes despite never surfacing, then G in (7) would be underlying *ʕ* and *ħ* (Bar-Lev 1977). Alternatively, two kinds of *ʔ* and *χ* can be posited, one of which triggers (7) and one of which does not (Bolozky 1978). The benefit of this alternative is that it does not require positing a highly marked segment in the inventory. Both of these approaches, though, involve a great deal of abstractness, which poses a problem from the perspective of learnability since, apart from this highly restricted process, no other evidence for these segments can be found (Faust 2005).

3.3 Vowel Lowering

The third process involving historical gutturals can be characterized as vowel lowering. The generalization observed is that vowels adjacent to gutturals are lower than non-gutturals in the same positions (e.g., [laʔamod] 'to stand' versus canonical [lilmod] 'to learn'). This general process is easily formalized in terms of a rule (10) and the generalization is readily captured in a constraint, the aforementioned (9).

(10) Vowel lowering (generic): V → [-high] / __G, vowels become [-high] before gutturals

The rule in its generic form is simple and straightforward. However, capturing the various nuances of the data involves complicating the rules significantly. To begin with, an underlying high vowel is sometimes lowered to a low vowel and sometimes to a mid vowel in the same phonological environment (e.g., [jaʔasok] 'he will engage in' versus [jeʔesof] 'he will gather', cf. canonical [yifsok] 'he will stop'). In addition, as with the aforementioned deletion and epenthesis processes, a great deal of sociolinguistic variability characterizes the data (e.g., formal [jeʔesof] 'he will gather' alternates with colloquial [jaasof] but [neʔesof] 'it is gathered' can only have mid vowels in any register). In addition, a few other rather particular idiosyncrasies exist; one such example is that a mid back vowel lowers to a low vowel but only when the guttural is the second root consonant of the future form of the *pa'al* conjugation class (e.g., [yigal] 'he will redeem', cf. canonical [yignov] 'he will steal'). Rather than phonological environment, the best predictor of the quality of the lowered vowel is the conjugation class of the verb, as can be seen in the following set of rules which are representative of those needed to account for the vowel lowering patterns.

(11) Vowel lowering 1: V → [-high] / __G, optional, in *pu'al* and *huf'al* conjugation classes and in some *pa'al* involving the historical ʔ
(12) Vowel lowering 2: V → [-high] / __G, obligatory, in *nif'al* and *hif'il* conjugation classes and in *pi'el* involving the historical ʔ
(13) Vowel lowering 3: $V_{[+high]}$ → [+low] / __G, in *pa'al* conjugation class

The rules needed to characterize the data all represent variations of the general rule (10) but with a significant amount of extra-phonological elements that need to be included.

In terms of constraints, the issue is even more problematic, despite the fact that the statement of vowel lowering in (9) is straightforward. Indeed, this single constraint motivates all of the attested repairs. The problem is that far too many repairs are attested. Indeed, if deletion is available, there is no need for any other repair process. Yet, this is not what we observe in the data. For example, the most straightforward output for an input such as the underlying /tiʔsof/ should be /tisof/, with the *ʔ* deleted. This violates only a MAX constraint in which consonants in the input must have output correspondences. However, the attested output is [taasof], which violates MAX in addition to at least three other constraints.[4] This is an example of the classic problem of opacity. As with other problems of opacity and OT, possible theoretical solutions include Stratal OT or Sympathy Theory (cf. Green's (2004) treatment of opacity in Modern Hebrew). From the perspectives of their use as simple descriptive tools, however, ranked constraints on their own cannot adequately describe the data.

3.4 Summary

Three general processes seem to emerge from the data: deletion, vowel epenthesis, and vowel lowering. Context-free deletion of laryngeals occurs in everyday usage, with *ʔ* consistently found at the beginning of prosodic boundaries. Vowel epenthesis consists of three processes, two of which are closely related. The third kind of epenthesis proves the most problematic since it applies to only some instances of surface *ʔ* and *χ*. Vowel lowering as a process is easy to state generally using rules and constraints, but it is much more challenging to capture its various nuances.

Using phonological tools to describe the data can be achieved with ordered rules but is not possible with ranked constraints without additional theoretical machinery or abandonment of strict parallelism. As simple descriptive tools, ranked constraints alone cannot accurately describe the data. Ordered rules can do so, but they require reference to register and morphological information, indicating that this pattern is not strictly phonological. The biggest issue that ordered rules encounter is the question of abstractness. How much abstractness needs to be posited in order to account for the observed distributions?

[4] These constraints are IDENT-IO (V), DEP, and a Paradigm Uniformity constraint. The first specifies that the vowel quality of the input and output should match, the second prohibits epenthesis, and the third states that all members of the same paradigm must have the same prosodic structure (Kager 1999, Faust 2005).

Several other questions are also raised with regard to this data set. What is the status of ʕ and ħ? Of ʔ and *h*? Why do vowel epenthesis and vowel lowering seem to have much in common (e.g., both involve low vowels, both seem to disfavor consonants adjacent to gutturals, etc.)? Yet, why are there so many fine distinctions among the various manifestations of these processes? What is the role of morphology in these processes?

4 Evolutionary Phonology

In an EP framework, synchronic patterns such as those in Modern Hebrew are accounted for by considering many sources of explanation, including phonetically-motivated sound change, extra-linguistic factors such as language contact and prescriptive norms, and cognitive factors such as analogical change (Blevins 2006, Blevins to appear). An EP analysis gives primacy to diachronic, phonetic, or extra-linguistic explanations for sound patterns, leaving the synchronic phonology with the task of explaining only those patterns that involve what is posited to be a speaker's mental representation of sounds and their relationships. A guiding assumption is that much detailed knowledge of language-specific sound patterns can be and is learned rather than existing a priori (Blevins 2004). With regard to the processes observed in the data – deletion, epenthesis, and lowering – the question arises regarding the extent to which they represent synchronic phonological knowledge. This section explores how extra-phonological factors relate to our understanding of these patterns, allowing us to see what explanations must be provided for by phonology.

4.1 Deletion and the Vowel Inventory

Of the three processes, the best candidate for a pure phonological explanation is deletion: it can be stated in strictly phonological terms, using rules or constraints that refer to categories of segments (consonants and vowels) and prosodic positions (syllable and word boundaries). Moreover, if we treat ʔ and *h* as the only gutturals in the phonemic inventory of Modern Hebrew, then we are also dealing with rules and constraints that involve a natural class. Otherwise, if historical ʕ is represented as synchronic ʕ, we are either not dealing with a natural class or we have to posit two identical rules. The notion of economy supports the idea that ʕ and ħ are not in the phonemic inventory.

An examination of the history of the language helps explain why the historical pharyngeals are no longer in the inventory. As mentioned in Section 2, Hebrew was not a natively acquired everyday spoken language for centuries until its revival in the late 1800s. The primary languages of the revivalists (e.g., Russian, German, Yiddish) did not include pharyngeals, so it is not surprising that they did not produce those sounds with Hebrew, acquired by them as a foreign language, when their children, using pharyngeal-less speech as the input, were acquiring it as a first language (Zuckermann 2009). Because their native languages had an array of vowels available, the revivalists could reproduce the vocalic effects of the gutturals, even if not the triggers themselves.

Further, their phonetic qualities explain why the pharyngeals ultimately took the particular shape they did, becoming less like one another. For instance, voiced pharyngeal fricatives have been shown to exhibit realizations that vary with regard to manner, such that the voiced pharyngeal fricative can sometimes be produced as an epiglottal stop (Esling 1999). This realization of ʕ would be expected to be very similar perceptually to ʔ, given that the two sounds are produced virtually identically, exhibiting only small differences in place of articulation. With regard to ħ, it is noteworthy that its constriction is typically narrower than for ʕ, likely to make up for the fact that it is a quieter sound (McCarthy 1994). It would not be surprising, then, that speakers would tend to narrow its constriction when creating clearer or more emphatic speech. Increasing its degree of turbulence makes it sound more like a voiceless uvular or velar fricative, sounds represented in the native languages (e.g., *x*, χ, and ʁ) of the Modern Hebrew revivalists (Zuckermann 2009).

In contrast to the pharyngeals, the laryngeals do seem to play some role in the modern variety. However, the fact that they are subject to widespread context-free deletion leads us to question their status as phonemes for at least some speakers. Given that the surface realization of these sounds is restricted to the formal register, it is certainly plausible that they are not phonemes for speakers who do not use the formal register. A prediction based on the hypothesis that the laryngeals are relevant only for high register would be that a sociolinguistic study would reveal that increased formality, higher levels of education, and more positive attitudes towards prescriptive

norms would all be associated with greater presence of surface *ʔ* and *h*. Since the deletion of *ʔ* and *h* may actually reflect a change in progress for the language as a whole, generational differences are also likely to be observed, with younger speakers using these sounds less than older speakers. Furthermore, if the laryngeals are a product of literacy, they are not expected in the speech of illiterate or preliterate speakers. Preliterate speakers in the process of learning to write would likely make many mistakes, both by omitting letters representing *ʔ* and *h* and by writing them when not required orthographically.

Indeed, this latter mistake of emergent writers is likely to also be reflected even in the speech of literate adults. Since laryngeals are consistently found only in formal speech, it is possible that speakers have come to view them exclusively as markers of high register, without necessarily having a clear awareness of their distribution. The association of a phonological characteristic with prescriptively sanctioned use of the language can be seen in an experiment in which participants whose metalinguistic awareness was activated and who were asked to speak correct Hebrew increased vowel reduction in unstressed syllables, both where the prescriptive standard calls for reduction and when it calls for retention (Ravid and Schlesinger 2001). A similar process has been anecdotally attested for *ʔ* in Modern Hebrew. For example, words like 'apple' or 'water', which are prescriptively pronounced [tapuaχ] and [maim], have been produced as [tapuʔaχ] and [maʔim] when the speaker is attempting to sound more formal. Indeed, this kind of rule inversion – insertion of *ʔ* in exactly the environment in which a deletion rule applied – would certainly be expected if speakers do not have strong phonological knowledge of the prescriptive distribution of *ʔ*.

4.2 Vowel Epenthesis/Lowering

Both vowel epenthesis and vowel lowering demonstrate a dispreference for gutturals adjacent to consonants and vowels with lower F_1. In other words, gutturals seem to co-occur with low vowels. An examination of the articulatory and perceptual properties associated with pharyngeals and laryngeals reveals that these distributional tendencies are phonetically motivated.

During the articulation of a pharyngeal, the epiglottis creates a constriction with the pharyngeal wall, involving the tongue root to such an extent that the two main articulators are considered the epiglottis and the tongue root (McCarthy 1994). The activity of the tongue root in the pharyngeal cavity tends to cause the dorsum of the tongue to lower (Laufer and Baer 1988). This configuration corresponds to low vowels (Bauman-Waengler 2011). From the acoustic side, pharyngeals are characterized by a high F_1, associated with low vowels (McCarthy 1994, Laufer and Baer 1988). Therefore, a high vowel near a pharyngeal is likely to facilitate both the production and perception of phonetic variants that sound more like mid or low versions of the vowels. Here we see one possible pathway for sound change, characterized as CHOICE in the EP framework (Blevins 2004): multiple phonetic variants exist for a phonological high vowel in the presence of a pharyngeal, many of which sound like mid or low vowels. Since these lower-sounding exemplars are frequent in the speech signal, speakers come to consider the prototype of high vowels in the context of pharyngeals as a mid or low vowel, leading to the phonologization of [-high] phonetic variants in presence of pharyngeals. Vowel lowering in this context has been observed for Biblical Hebrew and also plays a role in the Ablaut classes in Arabic (McCarthy 1991); in Salishan languages with pharyngeals (Montler 2004), such as Columbian Interior Salishan; in the Athapaskan language of Chilcotin; and in the Northwest Caucasian language of Circassian (Colarusso 2012).

These same phonetic facts can explain epenthesis in the environment of pharyngeals. Given the association of pharyngeals with a high F_1, it would follow that moving between a pharyngeal and another segment would involve a perceptible transitional element. This element could be construed by the listener as simply an additional cue to the presence of a pharyngeal. It might, however, also be perceived as an excrescent vowel with a high F_1. This ambiguity in the phonological identity of the transitional element could be the source of a sound change, specifically CHOICE in EP (Blevins 2004). A listener hearing the excrescent vowel could either consider it a phonetic side-effect of the transition between a pharyngeal and another sound or she could phonologize it as an epenthetic low vowel, leading to the genesis of vowel epenthesis observed in Biblical Hebrew and in various Bedouin Arabic varieties (McCarthy 1991). This phenomena of an excrescent vowel as part of a transition to or from a pharyngeal is most likely to occur in a context in which the difference in first formant values is most salient, such as between pharyngeals and non-low vowels.

This is precisely the context in which pre-guttural epenthesis (7) occurs. The various instances of vowel epenthesis in the context of pharyngeals, therefore, can all be traced to a common phonetically-motivated sound change involving the higher F_1 of pharyngeals. Moreover, this same phonetic effect is also associated with vowel lowering.

What about the laryngeals? Unlike the pharyngeals, since they are articulated at the larynx, they do not involve a great deal of activity in the vocal tract, often taking the configuration of surrounding segments (Pierrehumbert and Talkin 1992). Thus, they would not reasonably be expected to cause significant lowering effects on surrounding vowels or to lead to the percept of an excrescent low vowel, at least not to the degree that pharyngeals do. Despite the differences between pharyngeals and laryngeals, though, lowering effects have in fact been attested cross-linguistically for both *ʔ* and *h*. For example, in Klallam, a Central Salishan language of the Pacific Northwest, *ʔ* has been found to cause preceding non-low vowels to be lowered (Montler 2004). Aware of the fact that laryngeals are claimed to not affect tongue articulations, Montler notes that interactions of the tongue and laryngeal articulations are in fact attested for laryngeal features such as creakiness and breathiness, two features that correspond to *ʔ* and *h* respectively. Creaky vowels in particular have been found to have a higher F_1, a result of the raised glottis in the creaky articulation. Though breathiness in vowels is not typically associated with a higher F_1, vowel lowering before *h* has been attested in Kabardian, a Northwest Caucasian language (Colarusso 2012). For the reasons mentioned above for pharyngeals, the raising of F_1 that seems to be associated with some laryngeal features can lead to phonologization of vowel lowering and epenthesis. The fact that F_1 raising is not as strong for *ʔ* as it is for pharyngeals could account for lowering to mid rather than low vowels in certain cases of *ʔ* (e.g., [leesof] ‘to gather’ versus [laamod] ‘to stand’).

4.3 Analogical Reasoning

Analogical reasoning also seems to be active in the language. For one, the differential lowering effects are becoming more regular, leading to leveling in the paradigm (e.g., high vowels lowering to mid vowels in high register forms with the historical *ʔ* but lowering to low vowels, as in the rest of the guttural paradigm, in the colloquial register). Not all cases of analogical reasoning result in a globally more regular verbal system. Pre-guttural epenthesis patterns of the historical pharyngeals are extending to other cells in the paradigm. For instance, the prescriptive, historical form [bit͡sa] ‘it (masc) was performed’ is now typically pronounced [bit͡sea] even in formal contexts, thereby looking more like other, more common forms of that root. This results in less overall regularity in the verbal system since this form with the epenthetic low vowel is distinct from forms of the rest of the paradigm; yet, it is making the behavior of the root forms more regular. Analogical reasoning also helps to explain the overall behavior of the historical *ħ*, which, in the colloquial variety, greatly resembles that of the historical *k*, the other source of synchronic *χ*, and, therefore, the rest of the consonants. Thus, leveling and analogical extension in the colloquial variety seem to be making historically motivated distinctions less transparent.

5 Conclusions and Topics for Further Research

Accounting for the patterns of historical gutturals in Modern Hebrew can be only partially achieved using just phonological tools. Ordered rules of traditional Generative Phonology do a satisfactory job of describing the data, provided that a significant degree of abstractness and a great deal of morphological information can be incorporated into the rules. As to the latter stipulation, this speaks to the fact that these processes are not strictly phonological. With regard to amount of abstractness, the issue of learnability comes into play. As Faust (2005) argues, though it is theoretically possible for a child to deduce the existence of abstract forms that have no surface representation, if it is possible to establish the pattern without positing phonemes that never surface and that are considered highly marked in many phonological theories, then such an approach would be preferable from the perspective of learnability.

The basic tools of OT, ranked constraints, are not sufficient to describe the data on their own. This is not to say that it cannot be done, simply that it cannot be done without abandoning the strict parallelism of the classic OT model (as with Stratal OT) or introducing a high level of abstractness to the potential constraints (as with with Sympathy Theory). Though neither a genera-

tive nor an OT approach is refuted as a theoretical model, they both exhibit problems that can be remedied by expanding the scope of possible explanations.

EP allows for both a re-examination of phonology and an introduction of other factors in understanding the pattern of historical gutturals. Phonology does bear on Modern Hebrew patterns (after all, the processes of deletion, epenthesis, and lowering can indeed be categorized as phonological process in other languages), though not necessarily in the way conceptualized under a generative or OT approach. Laryngeal-deletion represents a phonological process that does appear to be active in the minds of at least some speakers, those with significant use of both the formal laryngeal-full and the colloquial laryngeal-less varieties. On the other hand, speakers with minimal exposure to the formal variety would be expected not to have the deletion process or, for that matter, the laryngeals themselves represented in their mental grammars.

With regard to vowel epenthesis and vowel lowering, these two processes also represent examples of potential phonological knowledge, as versions of them have been attested for varieties of Arabic, Salishan languages, and Caucasian languages. Indeed, these processes are also hypothesized to have been part of the phonology of speakers of older varieties of Hebrew. These patterns in Modern Hebrew, therefore, look like synchronic phonological effects because they once were. A look at the diachronic trajectory of the language allows us to understand how the phonetic effects triggered by gutturals may have become phonologized. Knowing about this phonetic source allows us to see why the multiple lowering and epenthesis processes have so much in common, and knowing about the distinct phonetic properties of each of the gutturals allows us to see why the patterns are subtly different for each sound. We can therefore understand the synchronic processes as vestiges of earlier phonology without having to posit that the phonology constitutes part of the Modern Hebrew speaker's mental representation. We can further account for trends in the data by looking at other factors, such as prescriptive norms, language contact, analogical change, that also help explain the data without needing to be encoded in the mental grammar.

This paper has claimed that many of the aspects of the patterns of Modern Hebrew that seem phonological are actually not. If the processes that we have been describing as vowel lowering and vowel epenthesis do not represent speakers' knowledge of sounds and their patterns, what kind of knowledge do they represent? The proposal of this paper is that the knowledge associated with these patterns is morphological. Hebrew morphology exhibits other patterns that deviate from the canonical pattern that do not reference phonology that are categorized according to the deviant root position (Coffin and Bolozky 2005). I propose that whatever tools are used to explain these morphological deviations, such as diacritics in a morpheme-based model or extension of word-schemas in a word-based model (Haspelmath and Sims 2010), should also be used to represent the linguistic knowledge involved with the historical guttural patterns of Modern Hebrew. Identifying the appropriate place of the Modern Hebrew historical guttural patterns in the linguistic system will make for a more parsimonious phonology and will also provide more information to the analyst seeking to characterize the morphological system of Hebrew and other Semitic languages. A fuller understanding of the connections between phonology and morphology allows us to make progress towards predicting directions of sound change and towards understanding how linguistic knowledge is represented in the mind.

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M.A./Ph.D. Program in Linguistics
The Graduate Center, City University of New York
New York, NY 10016
imontoya@gc.cuny.edu