Vowel Harmony in Yemeni IBBI Arabic: A Minimalist Approach

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Abstract

This article aims to provide a Minimalist analysis of Vowel Harmony in Yemeni Ibbi Arabic. Vowel Harmony has been tackled by a number of studies and scholars, employing several approaches such as segmental, suprasegmental, autosegmental. However, though valuable, these approaches fail to provide a unified and comprehensive account, an account which probes all the phonological aspects of Vowel Harmony, and that could be applied cross-linguistically. Therefore, in this article, we propose a Minimalist approach to the analysis of Vowel Harmony. The approach we propose accounts for the phonological processes underlying Vowel Harmony, requiring only the necessary empirical coverage with the least amount of theoretical assumptions and representations. Our proposal is based mainly on Mailhot and Reiss's (2007) conceptions of *Search* and *Copy* algorithm model, making use of Archiphonemic Underspecification Theory (Inkelas 1995; Reiss 2008) and linearization that is based on Chomsky's (1995) 'Bare Output Condition' and Idsardi and Shorey's (2007) linearization algorithm.

***Keywords*:** Minimalism, vowel harmony, Yemeni Ibbi Arabic, linearization, underspecification, *Agree, Transfer, Search, Copy, Spell-Out, Probe, Goal*

1. Introduction

Vowel Harmony (henceforth, VH) as in (1) is a universal phenomenon which almost all languages share, with varying degrees and different types.

(1) a. *ḥaquhum* 'their (M.Pl.) rights'

b. *ḥaqehen* 'their (F.Pl) rights'

In (1a), the word/morpheme *ḥaq* 'right' has the vowel ***u*** which is a result of the sound ***u*** in the suffix *-hum*. In (1b), the word *ḥaq*' will have the harmonized vowel ***e*** due to the harmonizing vowel ***e*** of the suffix *-hen*. How derivation takes place will be addressed in details in section 5.

Wriedt (2013, p. 1) defines VH as:

> a system of long-distance assimilation where one vowel in a domain (often a word) causes some or all other vowels in the domain to share a particular feature. These features are typically height, frontness/backness, roundness, nasality, or position of the tongue root

This definition is mainly concerned with sharing features among vowels whether within a domain or across domains. Walker (2012) points out that VH is a matter of a systematic agreement for a particular feature or features between vowels. Mailhot (2010) maintains that VH is a phonological phenomenon in which there are co-occurrence constraints on vowels within words.

VH exists in Arabic and its regional dialects. It is an important phonological phenomenon and it has been studied by several researchers using different theories and approaches. For example, Abu Salim (1986) conducts a study in VH in Palestinian Arabic where he finds that VH occurs when a given vowel segment acquires a specific feature in a specific context. Watson (1989) investigates VH using the Feature Geometry Theory. She concludes that VH is a phonological phenomenon where a vowel segment gets harmonized to a specific feature of another vowel segment based on the contextual environment where they occur. In other words, the spread of a specific feature is triggered by the contextual features of other vowel segments and this is best explained by Cole's (1987) 'parasitic harmony'. Watson's conclusion is based on the existence of both the trigger and target vowel segments conditioned by a specific context.

In our study, we have adopted the Minimalist Program (Chomsky 2000, *et seq*). We have applied the Minimalist assumptions and notions to analyze vowel harmony in Yemeni Ibbi Arabic. The most important operations we have made use of are *Search*, *Copy* and *Agree*. We argue that the derivation and representation of VH in the Minimalist approach is more adequate and straightforward than other approaches to the analysis of this phenomenon. We have also adopted linearization whose essentiality and necessity lies in its function, which states that phonological representations must be interpretable by/in the phonetics module. Another theory we have adopted is Underspecification Theory. We argue that Underspecification Theory in phonology works in a similar way to the notion of (un)interpretability theory of Feature Valuation (see e.g. Chomsky, 2000, *et seq*). The Minimalist representation is found to be very simple in that it does not pose any complexities to the derivation and it meets the Economy Principle (see Chomsky, 1995) in both representation and the processes which produces it.

The rest of the article goes as follows: in section 2, we present the nature of VH. In section 3, we outline the previous theories and approaches to VH, and how they each fail to provide a unified analysis of this phenomenon. Section 4 presents the proposed approach. Section 5 discusses VH in YIA under the proposed approach. Section 6 concludes the paper.

2. The nature of Vowel Harmony

Vowel Harmony is a phonological phenomenon which almost all human languages share. Some researchers such as Alfozan (1989) define it as the principle, which governs the vowels of neighboring syllables that should have similarity with each other. Some others argue that VH is a phenomenon where an alternation of a specific feature of a specific vowel segment takes place. Abu Salim (1986) maintains that Vowel Harmony refers to the process by which high front vowels acquire the feature [+round] in the context of high rounded vowels. Aoun and Philippe (1977) point out that VH is a long-distance phonological phenomenon where an influence of one vowel segment onto another takes place. These definitions suggest that VH occurs in terms of some phonological features such as *backness, roundness* and *frontness*. These features have a role to play in shaping the phonological system of a given language and how it works. In fact, features define segments and classes of segments, and how they affect each other in a phonological process, irrespective of whether these “features refer to acoustic or articulatory properties” (Samuels, 2009, p. 71). Hall (2007, p. 17) argues that the phonological component of any language:

> does not need to know whether the features it is manipulating refer to gestures or to sounds, just as the syntactic component does not need to know whether the words it is manipulating refer to dogs or to cats; it only needs to know that features define segments and classes of segments. The phonetic component does not need to be told whether the features refer to gestures or to sounds, because it is itself the mechanism by which the features are converted into both gestures and sounds.

With these definitions in mind, we propose a simple definition of VH based on the proposal we are advancing here. Vowel Harmony can be simply defined as a phonological process in which a vowel sound is affected by the preceding or following vowel sound, be it in *roundness, frontness* and/or *backness*. The resulting harmony of two (or more) sounds/segments is thus accounted in terms of *Search, Copy* and *Delete* operations under the Minimalist assumptions (cf. Chomsky (2000, *et seq*; Shormani, in press, 2017). The operation *Search* searches for similar features in the harmonizing vowel sound/segment, and *Copy* transfers these features onto the harmonized vowel sound/segment, resulting in *Spell-out* of the harmonized utterance. The operation *Delete* deletes the features at LF level of representation. We refer to the harmonizing vowel sound as *Goal* and the harmonized one as *Probe* where the latter becomes or carries the features of the former. The result of the *Probe-Goal* operation is the vowel harmony. This relation is rule-governed in the sense that it occurs where a rule is to be applied. This rule is best reflected by the existence of both the trigger and target vowel segments.

Due to the universal nature of VH, it has been studied and accounted for in many languages and dialects employing several approaches such as *linear, non-linear, segmental, suprasegmental, autosegmental, Optimality Theory,* etc. However, none of these approaches and accounts has come up with a unified analysis to such a phenomenon.

Vowel Harmony is of great importance to all linguists, especially phonologists, contrastive linguists and even second language specialists. Some linguists (see e.g. Samuels, 2009) show that VH even helps some learners to learn a language such as Turkish and Finnish. In some languages such as Turkish, VH is assumed to be an essential phenomenon to the linguistic system. Some linguists see VH necessary to understand the phonological system of a language/dialect, and how it works (see e.g. Watson, 1989, 1995).

3. Previous Approaches and Theories

Chomsky (1957) argues that a scientific approach to linguistic theory is based on the rigor of formal, explicit and generative account and on the move away from seeking a discovery. Chomsky (1957, p. 11) argues that:

> We can determine the adequacy of a linguistic theory by developing a rigorously and precisely the form of grammar corresponding to the set of levels contained within this theory and investigating the possibility of constructing simple and revealing grammars of this form for natural languages.

In relation to the topic of this study, the adequacy of a theory is governed by the assumptions and representations required to account for the VH, opaqueness and transparency. In other words, this study hypothesizes that the most adequate theory or account is the one which ensures the minimum amount of apparatus to account for VH. This is the nature of the proposed approach of this study which will be employed in analyzing the VH in YIA in section (5). Here, we will make a review of the previous approaches, theories and models and compare the proposed approach with such approaches.

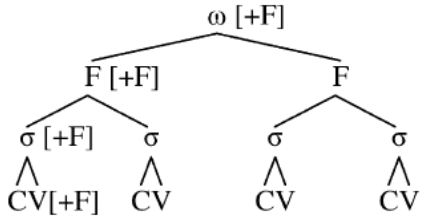
3.1. Feature-Percolation Model

Halle and Vergnaud (1981) propose a model where a feature such as [+F] is percolated up to the prosodic Word (ω). Samuels (2009, pp. 135-136) describing this method states that percolation takes place

> from the nucleus of one vowel—the one that "donates" its feature value to the alternating vowels—to the Prosodic Word (ω) node, and then down through the feet (Ft) and syllables (σ) to the other vocalic nodes in the word

This model is represented in Figure (2) below (from Neeleman and van de Koot (2006, p. 1536):

(2)



This model is somehow similar to the principle of Feature Inheritance of Chomsky (2008), but it is different in that it works haphazardly having no constraints to govern it (see also Radford, 2009). There are some shortcomings of this model. Neeleman and van de Koot (2006, pp. 1536-1537) argue against this model stating that "[u]pward percolation is not enough to model vowel harmony for the feature [+F]." The features " have no interpretation on syllables, feet or prosodic words." They emphasize that "there is a second process by which a feature can be copied downwards."

Along these lines, Samuels (2009) argues that given that this account is distinguished by the upward percolation, it lacks the downward percolation where the second, third, etc. vowels get valued for a specific feature. This means that percolation must go up and back down. She holds that because percolation of [+F] must go upward to the word level and then downward to the bottom, this model does not make any discrimination in where that [+F] is expressed. It means that every vowel segment will receive that feature specification. Neeleman and van de Koot (2006) add that downward percolation works against Chomsky's (1995) Principle of Inclusiveness which entails the "recoverability of the properties expressed on nodes in the hierarchy" (Samuels, p. 136).

Samuels (2009) points out that feature-percolation model entails the existence of "multilevel and hierarchical structure of phonological representation" (p. 137). She adds that this account is in need of a linearization process similar to the syntactic one, which converts the syntactic tree into a linear string of words in a sentence.

To conclude, Halle and Vergnaud's (1981) Feature-Percolation Model is thus still in need of "a bidirectional mechanism of percolation with copying of the percolated feature onto each node it passes and some notion of feature interpretability to keep the effects of [+F] confined to terminal nodes" (Samuels, 2009, p. 137). Our proposed model advanced in this study meets such a requirement in representing how VH is derived, processed and represented in the phonological component of the grammar.

3.2. Autosegmental Model

The autosegmental model was first proposed by Goldsmith (1976) and developed by other researchers in subsequent studies. In fact, the recent modified versions share in common the same working mechanism in the original one. In relation to VH, this model shows that the harmonic feature [+F] is in its own tier and its spread to other vowels takes place by means of association either within a morpheme or across morphemes. This means that each vowel and consonant can have its own independent tier, in that the harmonic feature "can be said to target all nodes on the vocalic tier without having to "skip" the intervening consonants" (Samuels, 2009, p. 136).

Describing this model, Samuels (2009) argues that the success of this account lies in that it does not require hierarchical structure to account for harmony process. Such an account is also characterized with its ability to account for directional cases where the edgemost vowels are not the source of the harmonic feature and harmony takes place in one direction. Compared to feature-percolation, Harmony in the feature-percolation account cannot take place in one direction because the harmonic feature must be percolated downward targeting every element dominated by the (W) word node.

Because the autosegmental model does not require a hierarchical structure or phonological tree, it means that it does not require linearization. This entails that for each X-tier, there has to be "a number of different autosegmental tiers, seemingly one per contrastive feature in a language" (Samuels, 2009, p.138). All these show that both feature percolation and autosegmental models require more structures and representations. Such complicated structures and representations place more burden on the language faculty and make processing such a phonological phenomenon very complex. Such complexities are against the nature of language which is defined by Chomsky (2005, *et seq*) as an optimal solution to link sound and meaning. The proposed approach in this study overcomes these complexities by providing a straightforward account of VH based on the Minimalist notions *Search* and *Copy*.

3.3. *Search*-Based Model (Nevin, 2004)

The *Search*-Based model is distinguished from other previous accounts, approaches and models by requiring less structured representations to account for VH. It involves a *Search* procedure, which in its working mechanism is similar to Chomsky's (2000, 2001) *Agree* operation in syntax. This account consists of three operations, namely *Search*, *Copy* and *Copy the Opposite*. A segment which is underspecified for a particular feature, initiates a parameterized *Search* looking for a close source in accordance with the Precedence Relations of Raimy (2000). The source feature is valued contrastive to the *Search's* feature value. Here, *Search* is conditioned by two choices. When the source is bounded to a specific domain, *Search* might end with a failure and hence receive the default value and this is explained clearly with both disharmony and dissimilation processes. This is what is meant by *Copying the Opposite* value. The other choice is *Copying* the target feature value onto the segment initiating *Search* and hence having harmony and assimilation processes.

What is good in this account is the binarity of feature value and the use of Raimy's (2000) Precedence Relation. In this aspect, Samuels (2009) argues that Nevin's (2004) model of harmony diverges from the autosegmental models in that it "can capture dependencies that run afoul of the NO Line-Crossing constraint on autosegmental representations" (p. 140).

As elaborated by Samuels (2009), the main problem of this account lies in the *Copy the Opposite* operation, which is not scientifically and empirically guaranteed. This operation deals with dissimilation and harmony in the same way, but this is not true because dissimilation is a phonological process that is very different from harmony. Therefore, it requires a different theory to be accounted for. In relation to opaqueness and transparency, Nevin's (2004) *Search*-based model deals with them as being properties of the vowels or the vowel system (see also Samuels, 2009). In our study, we argue that Nevin's (2004) concept of *Search* failure does not exist and it is refuted based on the idea that *Search* operation is rule-governed. In other words, when the context of an application of a given rule is available, *Search* is initiated to apply that rule to result in harmonizing two or more sounds in a particular context.

4. The Proposal

This study proposes a Minimalist analysis in both nature and character because it accounts for VH requiring only the necessary empirical coverage with the least amount of theoretical assumptions and representations. This proposed approach concerns how to apply the Minimalist assumptions to phonology dealing with this module as being a system of abstract symbolic computation divorced from phonetic content. It also investigates the universal core of formal properties that underlie all human phonological systems, regardless of the phonetic substance or the modality by which they are expressed (cf. also Samuels, 2009). In line with Samuels (2009), the proposed model seeks to prove that the phonological module has a position within the Minimalist conceptions of the architecture of grammar. In this way, our proposal seems to argue against Chomsky's (2008) and Pinker and Jackendoff's (2005) ideas of the non-existence of phonological design within Minimalism. Chomsky's (2008, p. 136) conception regarding phonology is that it is an 'ancillary' module. Therefore, the phonological systems seem to be "doing the best they can to satisfy the problem they face: to map to the [Sensory-Motor system] interface syntactic objects generated by computations that are ‘well-designed’ to satisfy [Conceptual-Intentional system] conditions”.

However, we can make a brief comparison between the Minimalist operations in narrow syntax and phonology. The Minimalist approach in the phonological module differs slightly from its application or computation in the syntactic module though both share the same operations which are *Merge*, *Move*, and *Spell-out* in syntax but *Search*, *Copy* and *Delete* in phonology. The operation *Merge* in syntax is replaced by concatenation in phonology. The operations *Search* and *Copy* replace the syntactic operations *Move* and *Agree*. *Delete* in phonology is an operation which indicates that phonological processing is now ready to undergo *Transfer*. *Delete* here is explained through the *Spell-out* operation.

The proposed approach is based mainly on Mailhot and Reiss (2007) *Search* and *Copy* Algorithm model, which is explained in section 4.1. below. Our proposal also makes use of the Archiphonemic Underspecification theory of (Inkelas, 1995; Reiss, 2008). Mailhot and Reiss’s (2007) *Search* and *Copy* Algorithm model employs linearization as an essential process in both phonological processing and representation and this linearization is based on Chomsky's (1995) 'Bare Output Condition' and Idsardi and Shorey (2007).

4.1. Mailhot and Reiss (2007) *Search* and *Copy* Algorithm

This account is based on the idea that segments are composed of features without which it is impossible to adequately show the relationship between harmonic segment vowels within and across a morpheme. It also assumes both the Distributed Morphology and Minimalist Syntax. Mailhot and Reiss’s (2007, p. 3) algorithm is presented in (3) below.

(3) *Search* algorithm

(1) *Search* ($\Sigma 0$, ς, γ ,δ)

i) Find all *x* in Σ subsumed by ς and index them:

$ς0, ς1,...,ςn$

ii) For each $i \in \{0, ..., n\}$:

(a) Proceed from $ς_i$ through Σ in the direction δ until an element subsumed by γ is found.

(b) Label this element γ_i.

iii) Return all pairs of coindexed standards and goals, ($ς_i$,γ_i).

(2) *Copy* (ς_i, γ_i, αF, C)

Identify αF on γ_i and assign αF to ς_i if the set of conditions C on γ_i are satisfied.

Thus, an application of *Search* will find one terminating point — the closest one in the appropriate direction — for each ς_i. The crucial point, however, is that *Search* proceeding from two distinct starting points, ς_i and ς_j, may terminate on a common *Goal*, returning pairs (ς_i, γ_i) and (ς_j, γ_j), where $\varsigma_i \neq \varsigma_j$, but $\gamma_i = \gamma_j$. Such a *Goal* will bear multiple indices: γ_i and γ_j. (cf. also Samuels, 2009, pp. 142-143).

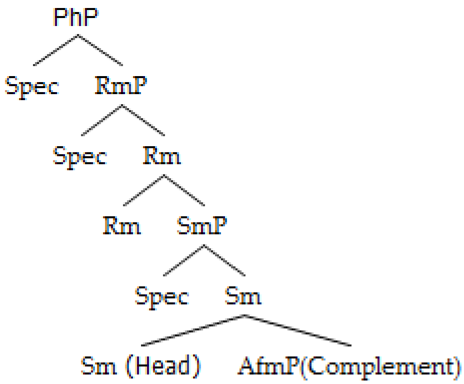
The Minimalist nature of this account lies in the necessary empirical coverage with the least amount of theoretical assumptions and representations in the sense that once the context of a rule application is available, both operations of *Search* and *Copy* are initiated and this initiation seeks for an *Agree* relation between a *Probe* and *Goal*. What this means is that the *Probe* searches for any local and closest *Goal* sharing its feature value but specified and valued. This specification or valuation between the *Probe* and *Goal* is a reflection of the principle of feature checking and valuation under the minimalist assumptions. In this study, the two terms of specification and valuation are used interchangeably.

Furthermore, Samuels (2009) argues that all the theories emphasize that alternating vowels, which enter the derivation are underspecified in that they lack a value for the harmonic feature. As a result, the initiation of both *Search* and *Copy* operations takes place locally and at distance. In this sense, Underspecification Theory in phonology is compared to the notion of Uninterpretable Feature of Chomsky (2008) who points out that the elimination of the uninterpretable features takes place by means of valuation which is introduced cyclically. To make it clearer, this theory or notion is what initiates the *Search* and *Copy* operations in a *Probe-Goal* relation, and this is because of a needy vowel segment to receive a feature value. In relation to opaque and transparent vowels, specification of features in the lexicon is the most suitable notion to account for their behavior.

Linear hierarchy/ linearization is also adopted in our study. Here, linearization takes place once the syntactic computation is finished in the narrow syntax by means of converting the hierarchal structured syntactic constituents into linear phonological strings or cycles. It sends theses strings in a sequence in order to be processed and checked by the phonological component. Linearization also is introduced to destroy the looped structures created by the operations of *Search* and *Copy* as soon as they are created (Samuels, 2009). As described by Samuels (2009), "phonological processes and operations such as linearization of looped structures get the chance to apply at each application of *Spell-Out*, and may apply across two adjacent *Spell-Out* domains but no more" (p.240).

4.4. The Proposed Schema

(4)



The above schema is proposed to represent the derivation of Vowel Harmony in the phonological component. Phonological Phrase (PhP) is the phrase which includes the head, its Specs and complements. Root Morpheme Phrase (RmP) hosts the original constituents or original lexical morpheme(s). Stem Morpheme Phrase (SmP) signifies the phonological computation that results in VH in both directions. Prefix Morpheme Phrase (PremP) is a morpheme which occupies the Specifier position of both the root and stem morpheme and it precedes the head. Suffix Morpheme Phrase (SufmP) is a morpheme which occupies the complement position of the head and it is in sisterhood relation with the head. Infix Morpheme Phrase (InfmP) is a morpheme which can be infixed in the head morpheme. Reduplicative Morpheme Phrase (RedmP) is a morpheme whose position is between the head and its complement.

5. Vowel Harmony in Yemeni Ibbi Arabic: A Minimalist Approach

After presenting our proposal in the previous section, we are in a position to apply it to the analysis of VH in Yemeni Ibbi Arabic. Thus, in this section we address how vowel harmony in the dialect under study is computed, derived and represented. The examples are limited to nominals within a morpheme and across morphemes. Consider (5) below:

(5) *ḥaquhum* 'their. M. Pl right'.

In this example, the derivation starts once the hierarchal structure is built and the syntactic constituents are ready to undergo *Spell-out*. It goes as follows: before *Spell-out*, the head root morpheme '*ḥaq'* enters the phonological module for phonological processing and checks. This root morpheme is not ready to undergo *Transfer* to the PF because of its accessibility to phonological operations. Because of this, the first cycle ‘*ḥaq’* waits until the second cycle enters the phonological module.

As soon as the root and its suffix morpheme, ‘*hum*’, get concatenated, phonological operations are triggered, and this is show by the unaccepted sequence of ‘*qh’*. In other words, it is due to the difficulty to pronounce this sequence. Before this, the addition of the epenthetic vowel, which represents the infix phrase results in the phonological process of re-syllabification in accordance with the Yemeni Syllabification Patterns (see e.g. Shormani, 2009), which is a phonological driven repair strategy, and this does not violate the (PIC) (see Chomsky (2000, p. 108)[1] and locality Principle because re-syllabification takes place internally within the whole phonological phrase. This sequence does not asymmetrically result in the *Spelt-out* form. As a result of this, the phonological checks and adjustments are introduced in the form of inserting an infix morpheme, which is underspecified for the feature value [+R] and inserted between the last segment of the first cycle ‘*ḥaq’* and the first segment of the suffix morpheme ‘*hum’* due to having sticky end, which makes both insertion and concatenation possible. At this stage, the first cycle represented by ‘*ḥaq’* undergoes *Spell-out*. In this sense, the stem morpheme ‘*ḥaq’* is inaccessible in accordance with the PIC. In other words, the phonological string is not visible to *Search* and *Copy* operations since the stem morpheme has its features valued and ready to be cyclically *Spelt-out*. Another reason, we suggest, is that the infix morpheme has to *agree* with its suffix morpheme, which functions as the subject of the whole phrase.

Now, we have the phonological strings concatenated in accordance with the linear order of the whole phonological phrase. Because the inserted vowel segment is underspecified for the feature value [+R], it is still visible to *Search* operation because it needs to value its feature value from any closest and local morpheme having a segment with the feature value [+R]. Therefore, this context triggers the *Search* operation in *a Probe-Goal* relation. *Searching* towards the first cycle ‘*ḥaq’* is inaccessible since its features are specified and valued, and the stem morpheme has been *Spelt-out*. Meaning the features of the first cycle are stored in the lexicon as it appears in the surface structure. Once the *Spell-out* of the stem morpheme takes place, linearization is applied in accordance with Raimy's (2000) Precedence Relation.

Now, the underspecified vowel segment of the inserted phrase initiates *Searching* from left to right until it locates the closest *Goal*, viz., ‘*hum’*, which

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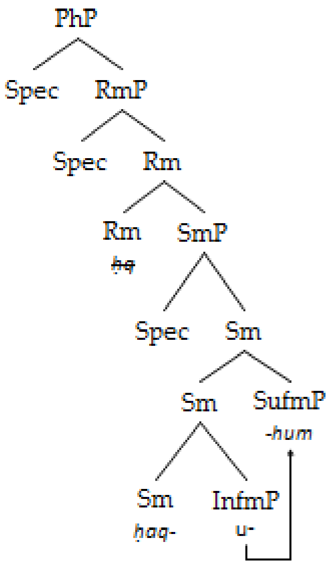
[1] Phase Impenetrability Condition (PIC), Chomsky (2000, p. 108):

In phase α with head H, the domain of H is not accessible to operations outside α, only H and its edge are accessible to such operations.

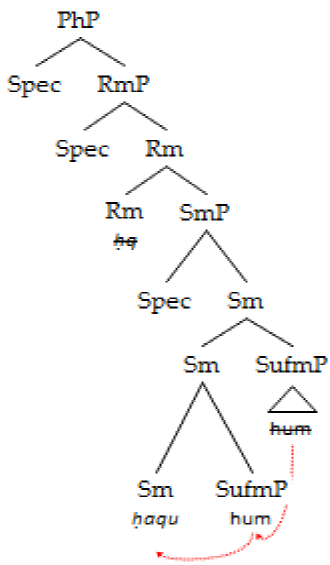
contains the feature value [+R]. Then the *Probe* of the *Search* copies that feature from the suffix morpheme, which represents the second cycle on to the underspecified segment by means of a *Copy* operation. *Search* and *Copy* operations result in an *Agree* relation, which is represented by the ϕ-features and [+R], and this is a rule-based agreement. This agreement is in the form of VH, which is partial since the influence and transmission of features take place from the suffix morpheme to the infix morpheme. The spread of the [+R] feature value from the right to the left underspecified vowel segment takes place post-lexically.

Once the process of specification is achieved by *Search* and *Copy* operations, *Spell-out* of both infix and suffix morphemes takes place in sequence. Once *Spell-out* takes place, linearization of the looped representations formed by *Search* and *Copy* operations takes place in accordance with the Precedence Relation mentioned so far. The derivation of this example is presented in (6a) and (6b) below.

(6a)



(6b)



Now consider (7) below which represents the plural form of the example in (5) above.

(7) *ḥuququhum* ‘their M.Pl. rights’

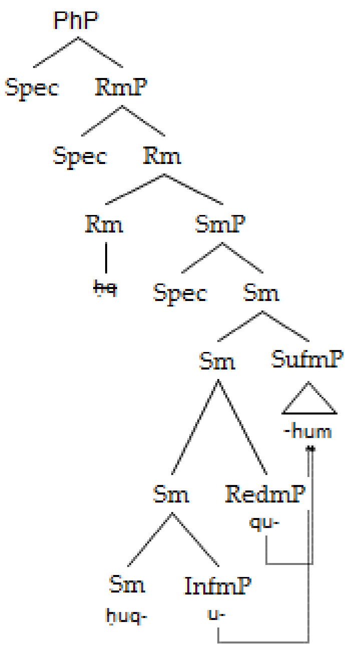
The derivation of this example follows the same procedure followed in (5) stated above. The difference lies in the application of the operations of *Search* and *Copy* to derive the reduplicative phrase '*qu'*, which forms a cycle in accordance with the process of re-syllabification. Here, after the insertion of the vowel segment of the infix morpheme, '***u***', which is underspecified for the feature value [+R], the application of *Search* and *Copy* operations to result in VH from right to left is not yet obtained. Once the insertion of the underspecified vowel segment between the last segment of the first cycle '*ḥuq'* and the first consonant segment of the suffix morpheme, '*hum'*, the phonological process of re-syllabification is applied, which results in the following template [CV CV CVC].

If we consider the *Search* and *Copy* operations for harmony of the underspecified vowel segment of the infix morpheme, '***u***', to take place after the reduplicative phrase's insertion to the linear string of the phonological phrase, we can say that another *Search* and *Copy* operations apply to obtain the plural of the abstract thing "right" through the introduction of reduplication phrase, '*qu'*, and this takes place via *copying* this syllable (after the process of re-syllabification) from the linear string in accordance with Raimy's (2000) Precedence Relation. In case that *Search* and *Copy* operations for harmony of the underspecified vowel segment of the infix morpheme, '*u'*, take place before the introduction of the reduplicative morpheme, '*qu'*, the derivation of the phonological phrase will have only one-to-one relation of a *Probe* and *Goal*. In case the first stipulation is emphasized, two-to-one relation of *Probe* and *Goal* relation is achieved. Here, the first view is favored for the derivation.

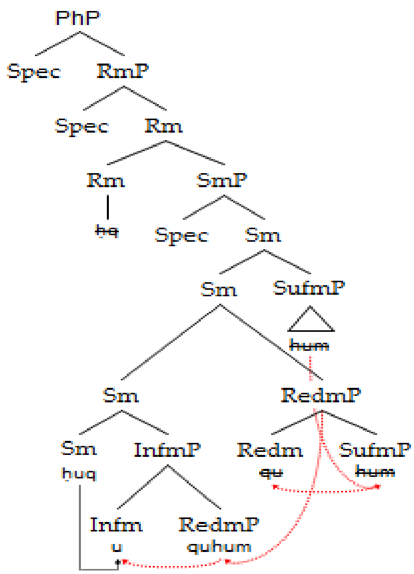
Once the asymmetric structure is obtained, another successful application of *Search* and *Copy* operations is triggered, taking place via *copying* the second syllable to which the vowel segment of the infix morpheme belongs and this results in a total reduplicative phrase represented by '*qu'*. At this stage, both underspecified vowel segments of the infix morpheme, '***u***'*,* and reduplicative morpheme trigger *Search* and *Copy* operations to search for the closest *Goal*, the suffix morpheme, '*hum'*, and *copy* its specified feature value [+R] back to the initiator of *Search* operation. This process of valuation is a reflection of an *Agree* relation.

Here, the working mechanism of the operations of *Search* and *Copy* is an indication of the *Agree* relation in narrow syntax. This *Agree* relation is established in which the vowel segments of the infix morpheme and reduplicative morpheme are donated their feature value [+R] and ϕ-features on the basis of what feature a followed morpheme is characterized with, and this is why the vowel segments of the infix and reduplicative morphemes take the feature value [+R]. Because of this, another process of re-syllabification is triggered. Now, we have the root morpheme, '*ḥuq*', which was at first characterized with the feature value [+Open] and because of the contextual feature value of the vowel segment of the infix morpheme, *'u'*, which is stronger than the feature value [+Open] of the root morpheme, the vowel segment of the root morpheme is influenced. This phonological influence triggers an operation of *Search* locating the feature value of the vowel segment of the infix morpheme as its closest *Goal* and then *copies* it back to its initiator of *Search*. All these operations function in accordance with feature checking, PIC, an *Agree* relation and locality principle, which allow looking back to the derivation. In this example, the influence of *Search* and *Copy* operations comes backward from the suffix morpheme into the infix morpheme and from the reduplicative morpheme into the root morpheme. It means that the spread of features takes place from right to left, regressively. Thus, the derivation of (7) is given in (8a), (8b) and (8c) below.

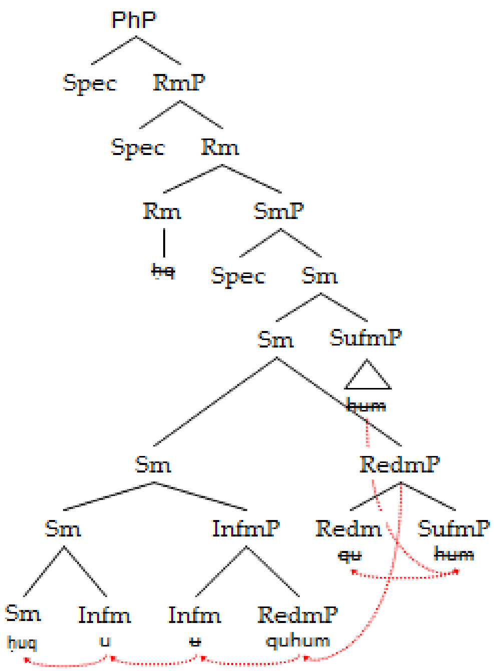
(8a)



(8b)



(8c)



Consider now (9) which is another form of (5) above, but signaling female gender.

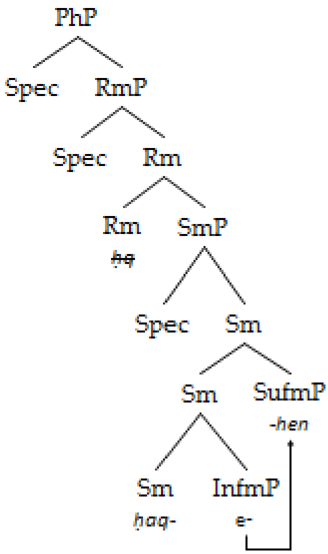
(9) *ḥaqehen* ‘their. F. Pl right’.

The minimalist derivation of this example goes until the whole phonological phrase is concatenated. Now, we have the phonological strings concatenated in accordance with the linear order of the surface structure. The inserted vowel segment, ***‘e’***, is underspecified for the feature value [+Open] and at the same time it is conditioned by the contextual feature of the suffix morpheme, ‘*hen*’. Here, the infix morpheme, ***‘e’***, appears to have the feature value [+Open], and it precedes a syllable, which is characterized by having [+H] that is front and half-close feature. Therefore, it is influenced by the contextual feature of the following morpheme, suffix morpheme, ‘*hen*’, which contains a vowel segment specified for the feature value [+H]. In Standard Arabic and perhaps in all modern Arabic varieties, the feature value [+H] is stronger than the feature value [+Open]. So, the feature value, [+Open], of the vowel segment of the infix morpheme is contextually changed to agree in all ϕ-features with the feature value [+H] of the following suffix morpheme, and this is represented by the change from the feature value [+Open] into [+H]. This is reflected through the visibility to *Search* operation because it requires establishing an *Agree* relation with its *Goal*. Therefore, this context triggers *Search* operation in a *Probe-Goal* relation. As we have postulated so far, this *Search* is parameterized in the sense that it identifies the type of feature it *searches* for and the direction of *Search* and the type of *Goal*.

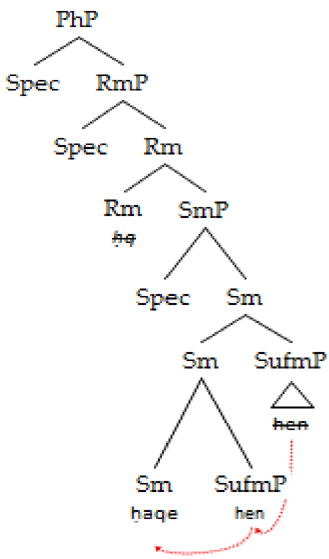
Searching towards the first cycle '*ḥaq'* is not allowed because its features are already valued in the lexicon and the stem morpheme, '*ḥaq',* has undergone *Transfer* to the PF. Once the S*pell-out* of the stem morpheme takes place, linearization is applied in accordance with Raimy's (2000) Precedence Relation. Now, the vowel segment of the infix morpheme initiates *searching* from left to right until it locates the closest *Goal* '*hen',* which contains the feature value [+H]. Then, the *Probe* of the *Search copies* that feature from the suffix morpheme, which represents the second cycle, on to the underspecified segment by means of a *Copy* operation.

All these operations of *Search* and *Copy* result in the establishment of an *Agree* relation, which is displayed by the ϕ-features and [+H]. This *agree* relation is in the form of VH, which is partial because transmission of features takes place from the suffix morpheme to the infix morpheme. The spread of the feature value [+H] from the right to the left underspecified vowel segment takes place post-lexically. The derivation terminates as soon as the process of specification is obtained by *Search* and *Copy* operations. Now, *Spell-out* of both infix and suffix morphemes takes place in a sequence and once *Spell-out* takes place, linearization of the looped representations formed by *Search* and *Copy* operations is ascertained again in accordance with the Raimy's (2000)Precedence Relation. This is further schematized in (10a) and (10b) below.

(10a)



(10b)



Now consider (11), which is another type of Vowel Harmony in YIA for the plural form of (9) above:

(11) *ḥuquqehen* ‘their F.Pl. rights’.

Unlike the previous examples, this example has two VHs and each one is different from the other in terms of the feature value it gets harmonized with. The derivation starts by sending the first phonological string, ‘*ḥuq’*. This string contains a vowel segment, which apparently seems to have the feature value [+Open]. This string is unable to undergo *Transfer* into PF because of having a sticky end in the last consonant segment, which makes *Search* for another string is something accessible. Then, linearization sends the second string, which is represented by the suffix morpheme, ‘*hen’*. The derivation starts by concatenating the two strings in order for phonological checks and adjustments to apply.

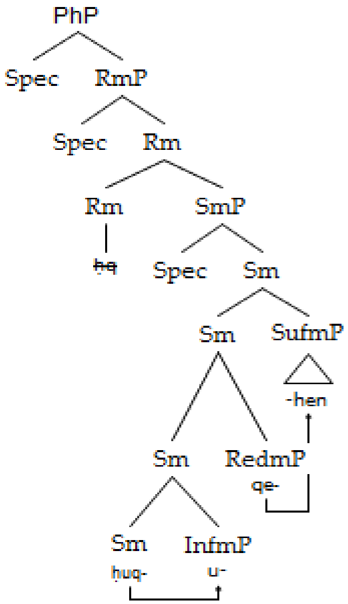
The first phonological check and adjustment are introduced, and this is clear by the unaccepted sequence of ‘*qh’*, due to the difficulty to pronounce this sequence. This requires the epenthesis of the epenthetic vowel, which represents the infix morpheme phrase. This addition triggers the *Search* operation to check both syllabification and re-syllabification in accordance with the Yemeni Syllabification Patterns (see e.g. Shormani, 2009). This addition is represented by inserting an infix morpheme, and this infix morpheme is introduced specified for the feature value [+H], and it inserted between the last segment of the first cycle ‘*ḥuq’*, and the first consonant segment of the suffix morpheme, ‘*hen’,* due to having sticky end, which makes both insertion and concatenation possible.

The process of concatenation does not stop at this stage and it is somehow different from the previous three examples because we still have the reduplicative morpheme, which needs to be concatenated and inserted into the phonological phrase. The difference also lies in the application of the operations of *Search* and *Copy* to derive the reduplicative phrase ‘*qe’*, which forms a cycle in accordance with the process of re-syllabification. Once the insertion of the specified vowel segment between the last segment of the first cycle ‘*ḥuq’* and the first consonant segment of the suffix morpheme, ‘*hen’*, the phonological process of re-syllabification is applied that results in the following template [CV CV CVC] (see also Shormani, 2009).

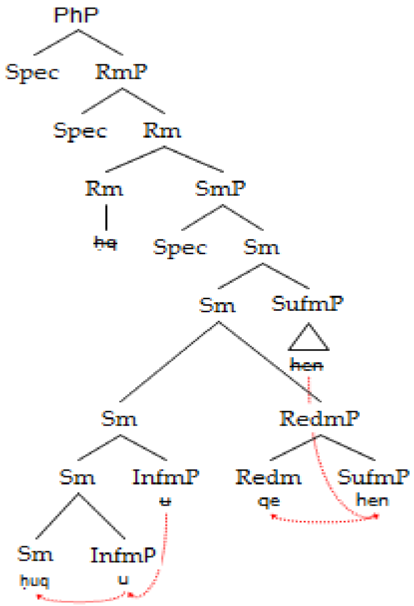
Here, the reduplicative morpheme, ‘*qe’*, is derived through the application of the operations of *Search* and *Copy*. *Copy* operation takes place partially because it only *copies* the first consonant segment of the second syllable, ‘*qu*’, but this reduplicative morpheme contains a vowel segment, which is underspecified for the feature value [+H]. This appears to have the following form ‘*qe’*. Now, we have the process of re-syllabification, which results in the template [CVC V CV CVC]. This derivation is based on Samuels (2009) who states that both reduplication, either total or partial, and affixation particularly infixation are two sides of the same coin. Here, the contextual feature in the phonological phrase initiates the operations of *Search* and *Copy*. This context exists because of the existence of the feature value [+Open] in the vowel segment of the first syllable of the stem morpheme '***ḥu****quqe'*, which is followed by the second syllable represented by the infix morpheme, which contains a vowel segment having the feature value [+R]. This sequence '***-ḥu*** *-qu -qe -hen'*, is difficult to be pronounced. Therefore, this difficult and to some extent unaccepted sequence initiates both operations of *Search* and *Copy,* and this is also due to the nature of the strong feature value [+R] of the vowel segment '***u'*** of the infix morpheme. The vowel segment of this string, '***ḥu****q', searches* through the whole phonological phrase and finds the vowel segment of the infix morpheme as its closest *Goal* and hence *copying* back its feature value [+R] into its vowel segment. This shows that we have two independent *Searches* within the same phonological phrase. In relation to the underspecified vowel segment of the reduplicative morpheme, it initiates *Search* operation and targets the vowel segment of the suffix morpheme and *Copy* its feature value [+H] back to its underspecified vowel segment.

All these operations function in accordance with feature checking, PIC, *Agree* relation and locality principle, which allow looking back to the derivation. The influence of *Search* and *Copy* operations comes backward because the first one concerns the vowel segment of the suffix morpheme '*hen'* with the reduplicative morpheme,*'****e****'*, and the second concerns the vowel segment of the infix morpheme '***u***' with '*ḥuq'*. It means that the transmission of features takes place from right to left, regressively. This is presented in the tree diagrams in (12a) and (12b) below.

(12a)



(12b)



It seems that VH in Yemeni Ibbi Arabic also covers other person specifications. In the previous examples, we discussed VH in relation to third person singular and plural, male and female. In the (13) below, however, we provide an example of VH in second person:

(13) *beitukum* 'your M. Sing. house'.

The minimalist derivation of this example begins when the first cycle, the root morpheme '*beit'*, which is specified for the feature value [+H], enters the phonological module. This morpheme is prohibited to undergo *Transfer* to the PF. Here, the root morpheme is already specified in the lexicon, meaning its vowel segment has its feature specified. What prevents the transference of this morpheme is parasitism, meaning phonological processing and checks are based on the concatenation of two morphemes together. Another reason is that if this phonological cycle is *Spelt-out*, it means that it is impossible for any root morpheme to escape alternations represented by, for example, opaqueness or transparency. As a result of this, the first cycle, '*beit',* waits until the second string, i.e., suffix morpheme, is sent to the phonological component specified for the feature value [+R].

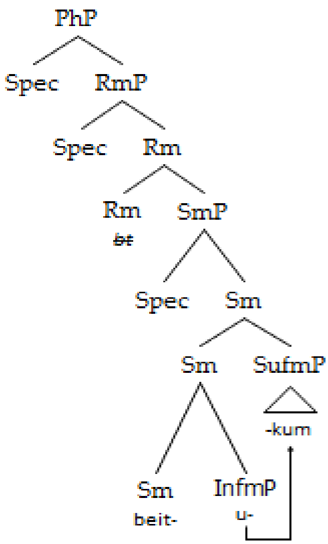
As soon as the root morpheme and its suffix morpheme, '*kum'*, are combined together, other phonological operations are activated and this is due to the not-allowed sequence of '*tk'*, which is two plosive sounds. In other words, because of the difficulty to pronounce this sequence, the phonological adjustment is introduced in the form of an infix morpheme, and this infix is presented underspecified for the feature value of the vowel segment of the suffix morpheme. It is inserted between the last segment of the first cycle *'beit'* and the first consonant segment of the suffix morpheme '*kum'* due to having a sticky end, which makes both insertion and concatenation possible.

The insertion of the epenthetic vowel, which represents the infix phrase results in the phonological process of re-syllabification, which is a phonological driven repair strategy and this does not violate PIC due to that re-syllabification takes place internally in the first phase (cycle) (cf. also Shormani 2016). This sort of phonological adjustment is repaired by the phonological operation of *Search*. At this stage, the first cycle, '*beit'*, undergoes *Spelt-out*. In this sense, the stem morpheme, '*beit'*, is no more accessible in accordance with the PIC and hence, is invisible to *Search* and *Copy* operations because it is already specified for a certain feature value and ready to be cyclically *Spelt-out*. Because the inserted vowel is underspecified for the feature value [+R], it is still visible to *Search* since it needs to specify and value its features from any closest and local donor. Therefore, it starts initiating *Search* operation as a *Probe* to locate any closest *Goal* having that feature value, but valued.

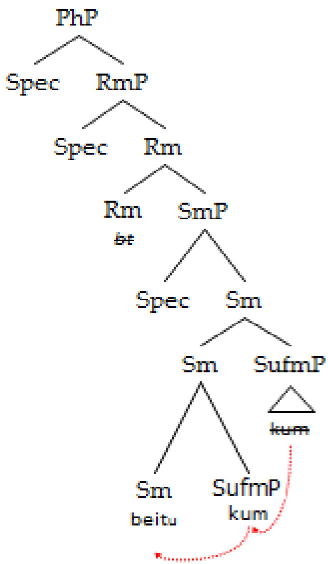
Now, the underspecified vowel segment of the inserted phrase, '***u***', initiates *Search* from left to right until it locates the closest *Goal* '*kum',* which contains the feature value [+R]. Therefore, the *Probe* of the *Search copies* that feature value of the vowel segment of the suffix morpheme back on to its underspecified vowel segments. All these come out with a partial harmony from the right to the left, meaning regressively. The specification of the feature value [+R] of the infix morpheme is obtained post-lexically.

Here, the end of the minimalist derivation is marked by the specification and valuation of all morphemes. Now, *Spell-out* of both cycles takes place in sequence. When *Spell-out* is applied, linearization of the looped representations formed by *Search* and *Copy* operations is introduced in accordance with the Precedence Relationship of Raimy (2000). This is shown in (14a) and (14b) below.

(14a)



(14b)



In the previous examples, we consider examples of VH across morpheme(s). In the following example, we will consider an example of VH within morpheme. Consider (13 below:

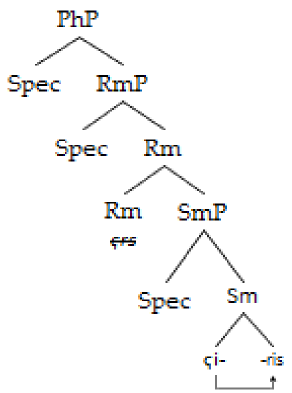
(15) *çiris* ‘wedding’.

The derivation of VH in this phrase ‘*çiris’* starts by sending the first phonological cycle ‘*ris’* by linearization to the phonological component specified for the feature value [+H]. This phonological string is not ready to undergo *Transfer* due to the visibility to the operation of *Search*. This visibility is because of the existence of a sticky end between ‘*ris’* and the first consonant segment. Therefore, it requires the first cycle to wait for any possible phonological string/cycle to enter the phonological component to be concatenated with. The phonological component receives the second cycle, which includes a vowel segment, whose feature value for [+H] is underspecified. Because phonological operations are parasitic, which is dependent on the concatenation of two morphemes or cycles, the already-present cycle concatenates with the newly-introduced one. As soon as the concatenation is complete, an operation of *Search* is triggered to check syllabification pattern and if it is in accordance with the Yemeni Syllabification Patterns, other phonological modifications are successively introduced and if not, the operation of *Search* re-syllabifies that strings accordingly.

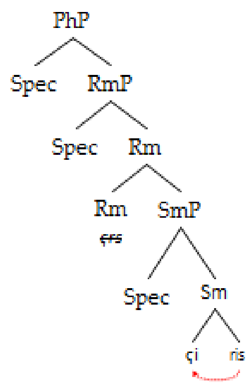
Once the first *Search* operation is finalized, the vowel segment of the second phonological cycle is visible to the operations of *Search* and *Copy*. Therefore, it needs to form an *Agree* relation in a *Probe-Goal* relation to specify its underspecified feature value [+H]. What is to be consider is that all *Search* and *Copy* operations are parameterized in the sense that it is based on the matching of features. Here, *Search* is initiated and finds the vowel segment of the first phonological string shares its feature, but specified. Therefore, it *copies* the feature value of the *Goal* back to its underspecified vowel segment and, hence valuing its unvalued feature. Once this valuation is obtained, both strings are ready to undergo *Transfer* to the PF component.

Here, the resulted harmony is total and regressive because the spread of features takes place from right to left. This harmony takes the form '*Fiçil'* "measure", which is accepted in Yemeni dialects. Once *Spell-out* of the phrase of the stem morpheme, '*çiris',* takes place, linearization is immediately introduced to destroy the looped representations formed in accordance with Precedence Relation mentioned so far and changes these looped representations into a linear string, which asymmetrically reflects the surface form. Here, both trees apparently seem not to indicate any conceptualized difference in achieving VH, but there is a difference, and this difference is not shown in the tree (16b) because VH takes place within a morpheme. This is further shown in (16a) and (16b) below.

(16a)



(16b)



6. Conclusion

This article comes up with several essential conclusions. First, it argues against the assumptions made in Chomsky (2008) and Pinker and Jackendoff (2005) that Minimalism does not provide anything for phonology, and hence excluding phonology from the human FL. Second, the phonological knowledge is part of UG and hence has a "place" within the FL. Third, we consider equating and/or matching syntactic operations to phonological operations. For example, the syntactic operation of *Merge* is equated with the phonological operation concatenation and the operations of *Move* and *Agree* are equated with the phonological operations of *Search* and *Copy*. We have argued that both components, viz. syntax and phonology share linearization, but they differ in its output since the syntactic linearization comes out with a nested hierarchal structure, whereas phonological linearization comes out with a linear hierarchal order. Linearization in syntax can be applied at the end, whereas in phonology it is applied at the beginning, within and at the end of the phonological processes.

The proposal advanced in this article suggests that phonological derivations including VH can be optimally done simply by the computation operations of *Search*, *Copy* and *Delete,* and sometimes *Agree*. The simplicity of the proposed approach is reflected through the derivation and computation, as well as representation of VH in Yemeni Ibbi Arabic. As far as Vowel Harmony in YIA is concerned, it seems that the proposed analysis advanced in this article accounts simply and straightforwardly for computing and representing it. It is hoped that our proposal will have a cross-linguistic appeal. Applying this proposal to other languages is substantial and we leave this for future studies.

References

Abu-Salim, I. (1986). Vowel harmony in Palestinian Arabic: a metrical perspective. *Journal of linguistics*, *23*(1), 1-27.

Alfozan, A. (1989). Assimilation in Classical Arabic: a phonological study. (Doctoral Dissertation), Glasgow University.

Aoun, J. and Philipp, M. (1977). *Vowel harmony*. San Diego: University of California.

Chomsky, N. (1957). *Syntactic structures* (2nd. ed.). Berlin, Germany: Mouton de Gruyter.

Chomsky, N. (1965). *Aspects of the theory of syntax.* Cambridge, MIT Press.

Chomsky, N. (1966). *Cartesian linguistics*. New York: Harper & Row.

Chomsky, N. (1995). *The minimalist program*. Cambridge, MIT Press.

Chomsky, N. (2000a). Internalist explorations. In N, Chomsky. (ed.), *Language as a natural object. In New horizons in the study of language and mind*. Cambridge University Press.

Chomsky, N. (2008). On phases. In Freidin, C. Otero, and M. Zubizarreta, (eds). *foundational issues in linguistic theory: Essays in honor of Jean-Roger Vergnaud*, (pp. 133‑166). Cambridge: MIT Press.

Cole, J. (1987). *Planar Phonology and Morphology* (Doctoral Dissertation). Cambridge: MIT.

Goldsmith, I. (1976). *Autosegmental phonology* (Doctoral Dissertation). MIT.

Hall, D. C. (2007). The role and representation of contrast in phonological theory. (Doctoral Dissertation), University of Toronto.

Halle, M., and J-R. Vergnaud. (1981). Harmony processes. In W. Klein & W. J. Levelt, (eds), *Crossing the boundaries in linguistics: studies presented to Manfred Bierwisch*, 1–22. Dordrecht: D. Reidel.

Idsardi, W., & Shorey, R. (2007). Unwinding morphology. Paper presented at the CUNY Phonology Forum Workshop on Precedence Relations.

Inkelas, S. (1995). The consequences of optimization for underspecification. *Proceedings of NELS, 25*, 287‑302.

Mailhot, F. (2010). Instance-based acquisition of vowel harmony. *Proceedings of the 11th Meeting of the ACL Special Interest Group on Computational Morphology and Phonology*. *Association for Computational Linguistics,* 1-8.

Mailhot, F., & C. Reiss. (2007). Computing long-distance dependencies in vowel harmony. *Biolinguistics, 1*(1450–3417), 28‑48.

Neeleman, A., and H. van de Koot. 2006. On syntactic and phonological representations. *Lingua* 116:1524–1552.

Nevins, A. (2004). *Conditions on (dis)harmony* (Doctoral Dissertation). MIT.

Pinker, S., & R. Jackendoff. (2005). The faculty of language: What is special about it? *Cognition, 95*(2), 201‑236.

Radford, A. (2009). *Analyzing English sentences: A minimalist approach*. Cambridge University Press.

Raimy, E. (2000). *The Phonology and Morphology of Reduplication* [*Studies in Generative Grammar 52*]. Germany, Berlin: Mouton de Gruyter.

Reiss, C. (2008). Constraining the learning path without constraints, or the OCP and NoBanana. In B, Vaux & A, N. (eds.), *Rules, constraints and phonological phenomena,* (pp. 252-301). Oxford: Oxford University Press.

Samuels, B. (2009). *The* structure of phonological theory. (Doctoral Dissertation), MIT.

Shormani, M. (2009). Syllable structure and syllabification in Yemeni and Indian Arabic. A paper presented at the 32nd All-India Conference of Linguists (32AICL), held on 21-23 December 2009, Centre for Applied Linguistics and Translation Studies, Hyderabad University, Hyderabad, India.

Shormani, M. (2016). Are Noun Phrases Phases? Evidence from Semitic Construct State. *International Journal of Arabic Linguistics*. 2(2), 196-132.

Shormani, M. (2017). SVO, (silent) topics and the interpretation of referential pro: A discourse-syntax interface approach. Italian Journal of Linguistics, 29(2). 91-159.

Shormani, M. (in press). *Introducing minimalism: A parametric variation*.

Walker, R. (2012). Vowel harmony in optimality theory. *Language and Linguistics Compass, 6* (9), 575-592.

Watson, J. (1989). *Aspects of the phonology and verb morphology of three Yemeni dialects* (Doctoral Dissertation). SOAS.

Watson, J. (1995). Vowel Harmony in Arabic. *CMEIS,* University of Durham, DHI3T.

Wriedt, Q. (2013). *Vowel harmony in Maasai* (Doctoral Dissertation). US, *ProQuest LLC.*