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A Choice between Faithfulness and Stress: A Metathesis Process in Qassimi Arabic

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ABSTRACT

This paper deals with an instance of phonological optionality that arises in the speech of older Qassimi Arabic (QA) speakers where a vowel can optionally surface in two positions: underlying position (e.g. [(ˈjat).bə̲.ʕuh] 'he follows him') and unfaithful metathesized position (e.g. [ja.(ˈtə̲b).ʕuh] 'he follows him'). It primarily aims to answer the following questions: 1- How is this phonological optionality accounted for? 2- Which phonological models of variation can capture and correctly produce all and only the attested forms? Basing the analysis on a metrical account of the QA stress system, the paper shows that the unfaithful vowel site is motivated by assigning primary stress closer to the right edge of the word, which is a tendency in QA. This is empowered by the markedness constraint Align (ˈσμμ R, wd, R) which aligns heavy stressed syllables with the right edge of the word. The other vowel site is motivated by the faithful anti-metathesis constraint linearity, which requires outputs to have the same segment order as the input. The paper shows that only Partial Order Grammar and Noisy Harmonic Grammar can accurately produce the QA optionality. The present paper connects phonological optionality to larger grammatical parameters and tendencies. It also tests the cross-linguistic viability and applicability of widely used variation models by running data from an understudied/underdocumented variety of Arabic against them.

Keywords: Metathesis; Optional; Stress; Phonological Variation

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1. 1. Introduction

Accounting for phonologically optional processes often requires scrutinizing the interaction of various components of the grammar. These optional processes, including the current one, often stem from a conflict between satisfying a grammatical parameter and staying faithful to the input.

This paper examines and provides an analysis for a phonologically optional process that is manifested in the speech of older native speakers (65 of age and older) of Qassimi Arabic (henceforth QA), which is an understudied/underdocumented variety of Arabic.

Older QA speakers show variation in syllable structure where a vowel occurs in either of two positions (see **Table 1**). The underlined schwa in these examples can apparently swing between two positions where it is unfaithfully hosted by a closed stressed medial syllable in one position while it is faithfully hosted by an open unstressed medial syllable in the other position. Unlike older QA speakers, younger QA speakers only produce the faithful variant.

Table 1. QA Older Speakers' Variation.

Underlying Representation	Variant 1	Variant 2	Meaning
(a)/jatbə̲ʕ+uh/	[ja.ˈtə̲b.ʕuh]	[ˈjat.bə̲.ʕuh]	'he follows him'
(b)/jasmə̲ħ+en/	[ja.ˈsə̲m.ħen]	[ˈjas.mə̲.ħen]	'they allow/permit'
(c)/ikrə̲m+ah/	[i.ˈkə̲r.mah]	[ˈik.rə̲.mah]	'be generous with her'
(d)/itˤʕə̲m+uh/	[i.ˈtˤə̲ʕ.muh]	[ˈitˤ. ʕə̲.muh]	'feed him'
(e)/nagrə̲sˤ+ah/	[na.ˈgə̲r.sˤah]	[ˈnag.rə̲.sˤah]	'we sting her'

The study mainly aims to answer the following questions:

- How is this phonological optionality accounted for?
- Which phonological models of variation can capture and correctly produce all and only the attested forms?

The proposed analysis ties the phonological optional process to different aspects of the grammar. It achieves this by examining the interaction between the present phonological variation (the terms "phonological variation" and "phonological optionality" are used interchangeably throughout this paper) and QA stress parameters and tendencies. The analysis is then tested against several widely used models of variation, namely, Partial Order Grammar (henceforth PO) [1–3], Maximum Entropy (henceforth MaxEnt) [4], and Noisy Harmonic Grammar (henceforth NHG) [5]. It is shown that only PO and NHG can model the optionality process in question.

In this paper, I argue that the vowel in the unfaithful variant metathesizes to satisfy a QA stress tendency of placing primary stress closer to the right edge of the word [6]. The other variant, on the other hand, stays faithful to the input at the expense of dissatisfying the QA stress tendency.

From an Optimality Theory (henceforth OT) [7] perspective, the unfaithful variant better satisfies Align (ˈσμμ R, wd, R) [8], which requires heavy stressed syllables to occur nearest the end of the word. The satisfaction comes at the expense of incurring a faithfulness violation of the anti-metathesis constraint Linearity [9].

The present paper is structured as follows: Section 2 explains the data in more detail. Section 3 demonstrates how the QA stress system functions and develops an OT account of it. Section 4 addresses the two research questions, employing the OT metrical account developed in section 3 is employed as the foundation for the optionality analysis. This section also tests the optionality analysis against the aforementioned models of variation. Section 5 concludes the paper.

2. The Data

When vowel-initial suffixes are attached to verbs of the shape /(C)VC.C**V**C/, older QA speakers exhibit variation in which the second underlying vowel can occur either in its underlying position [ˈ(C)VC.C**V**.CVC] or in a metathesized position [(C)V.ˈC**V**C.CVC]. In the faithful variant, where the vowel occurs in its underlying position, primary stress falls on the initial closed syllable, whereas in the unfaithful metathesized variant primary stress falls on a medial closed syllable. The concrete examples can be founded in **Table 2**.

Table 2. QA Older Speakers' Variation.

Underlying Representation	Variant 1	Variant 2	Meaning
(a)/jatbə̲ʕ+uh/	[ja.ˈtə̲b.ʕuh]	[ˈjat.bə̲.ʕuh]	'he follows him'
(b)/jasmə̲ħ+en/	[ja.ˈsə̲m.ħen]	[ˈjas.mə̲.ħen]	'they allow/permit'
(c)/ikrə̲m+ah/	[i.ˈkə̲r.mah]	[ˈik.rə̲.mah]	'be generous with her'
(d)/itˤʕə̲m+uh/	[i.ˈtˤə̲ʕ.muh]	[ˈitˤ. ʕə̲.muh]	'feed him'
(e)/nagrə̲sˤ+ah/	[na.ˈgə̲r.sˤah]	[ˈnag.rə̲.sˤah]	'we sting her'

The present paper exams the phonological optional process in question as a metathesis process motivated by satisfying a QA stress tendency to place primary stress nearest the end of the word. The underlying representation is the present-tense base form of the verb before adding the vowel-initial suffix (i.e. the word that precedes the plus sign in the underlying representation in (2)). This widespread approach of taking the present-tense base form of the verb as the underlying, assumes that the vowel is present underlyingly [10–12].

3. QA Stress

Stress assignment is central to resolving the puzzle addressed in this paper, motivating the optionality in question. QA is a default-to-opposite language, in particular, it is a default-to-left language where in the absence of heavy syllables, primary stress falls on the initial syllable **Table 3 (a)**, and in the presence of heavy syllables, primary stress is assigned to the rightmost heavy syllable [13,6,14]. The CVC is heavy only when it occupies a non-word-final position **Table 3(e)**, whereas the CVVC, CVCC and CVV are always heavy (i.e., stress-attracting) regardless of their position in the word **Table 3(b)**, **Table 3(c)** and **Table 3(d)**). The QA stress system is exemplified in **Table 3**.

The optionality analysis is based on Alnuqaydan's [6] metrical account of the QA stress system (see **Table 4**). Alnuqaydan proposed the following constraint ranking which is explained below.

Table 3. QA Stress Patterns.

Syllable Shape	Example	Meaning
(a) Initial stressed syllable in the absence of heavy syllables	[ˈɑ.sa.fan]	'apology'
	[ˈba.gaʔ]	'he stayed'
(b) CVVC	[je͡ʤ.ħa.ˈduun]	'they (m) keep it a secret'
	[ju.ru.ˈħuun]	'they (m) go'
	[ˈhaa͡ʤ.ri]	'travel (2fsg)'
(c) CVCC	[ik.tu.ˈtibt]	'I have been written down'
	[ʃa.ˈraħt]	'I explained'
	[ˈgist.wah]	'you (mpl) measured it/her'
	[d͡ʒa.ˈraħt.wah]	'you (mpl) hurt it/her'
(d) CVV	[bi.ˈlii]	'he was accused wrongfully'
	[mis.ˈtaa.ħiʃ]	'he is scared'
	[ˈħaa.sid]	'envious'
(e) CVC	[ʃi.ˈraħ.tah]	'I explained it'
	[ˈχeb.reh]	'experience'

Table 4. Alnuqaydan's [6] Constraint Ranking for the QA Stress System.

FTBIN, SWP >> ALIGN (ˈσμμ R, wd, R) >> ALLFT-L >> AllFT-R, Parse- σ

The default setting of the stress system where primary stress falls on the initial syllable in the absence of heavy syllables, is derived by ranking the alignment constraint ALLFT-L[8] above its counterpart ALLFT-R [8]. ALL-

FT-L requires the left edge of each foot to be aligned with the left edge of the prosodic word. AllFT-R, on the other hand, requires the right edge of each foot to be aligned with the right edge of the prosodic word.

To stop iterative footing and produce only primary stress, AllFT-L must also outrank Parse-σ [8] which requires all syllables to be parsed into feet. **Table 5** shows the interaction between these constraints.

The candidates **Table 5(b)**, **Table 5(d)**, and **Table 5(e)** are ruled out by AllFT-L for failing to align the left edge of the foot with the left edge of the prosodic word. The candidate **Table 5(c)** is ruled out by Parse-σ for containing two unparsed syllables. This exclusion applies even earlier once FTBIN is introduced in the following tableau. FTBIN will also exclude *[(ˈɑ.sa.fan)] which has a ternary foot including all of the syllables.

Table 5. Words with Light Syllables.

/ɑsafan/	AllFT-L	Parse-σ	AllFT-R
(a) (ˈɑ.sa).fan		*	*
(b) ɑ.(ˈsa.fan)	*!	*	
(c) (ˈɑ).sa.fan		**!	**!
(d) ɑ.(ˈsa).fan	*!	**	*
(e) ɑ.sa.(ˈfan)	*!*	**	

Note: the asterisk "*" indicates a violation of the constraint. "**" means that the candidate violates this constraint twice. The exclamation mark "!" indicates the violation that rules out the candidate. A candidate having more than one exclamation mark under two different constraints (e.g. [(ˈɑ).sa.fan]), means that these constraints are not ranked with respect to each other.

AllFT-L cannot be undominated; otherwise, primary stress will always be placed on the initial syllable. QA quantity sensitivity is formalized by the markedness constraints Stress-to-Weight Principle (SWP) [15,16] and FTBIN [15,16,7]. SWP requires each stressed syllable to be heavy. It is worthy of mention that SWP is chosen over Weight-to-Stress Principle (WSP) [15,16] because the status of secondary stress is unclear in QA. The use of WSP instead will make assumptions about secondary stress that cannot be tested nor proven [6]. Also, a word that does not have stress vacuously satisfies SWP. That is why Alnuqaydan [6] assumes that Culminativity [17], which penalizes a word without stress, is undominated in QA and must also outrank SWP. FTBIN, on the other hand, requires feet to be exactly binary at the moraic level. This is supported by the fact that QA syllables have been assumed to be maximally bimoraic [13,6]. In QA, all light syllables are monomoraic. Heavy and superheavy syllables are bimoraic. A foot in QA can only be binary at the moraic level if it encompasses two light syllables or one heavy/superheavy syllable. SWP and FTBIN must outrank AllFT-L for non-initial heavy syllables to receive primary stress, as shown in Table 6 and Table 7.

In **Table 6**, all the suboptimal candidates with different foot configurations necessarily violate FTBIN. Therefore, FTBIN is all that is needed to choose the correct winner.

Table 6. Words with One Middle Heavy Syllable.

/ʃiraħtah/	SWP	FTBIN	AllFT-L	Parse-σ	AllFT-R
→a) ʃi.(ˈraħ).tah			*	**	*
(b) (ˈʃi.raħ).tah	*!	*!		*	*
(c) ʃi.(ˈraħ.tah)		*!	*	*	
(d) (ˈʃi).raħ.tah	*!	*!		**	**
(e) ʃi.raħ.(ˈtah)	*!	*!	**	**	
(f) (ˌʃi).(ˈraħ).tah	*!	*!	*	*	***

Note: the asterisk "*" indicates a violation of the constraint. "**" means that the candidate violates this constraint twice. The exclamation mark "!" indicates the violation that rules out the candidate. A candidate having more than one exclamation mark under two different constraints, means that these constraints are not ranked with respect to each other.

In **Table 7,** SWP does all the work. It is violated by all the non-winning candidates. Candidate **Table 7(b)**, in particular, shows the significance of ranking SWP above ALLFT-L. This candidate does not violate FTBIN. Candidate **Table 7(e)** demonstrates the importance of employing SWP instead of WSP, as Alnuqaydan [6] pointed out. This candidate would not violate WSP, which would end up winning the competition and ruling out the actual surface form since, unlike the actual surface form, it fully satisfies PARSE-σ. QA quantity sensitivity is now formalized.

Table 7. Words with One Final Heavy Syllable.

/juruħuun/	SWP	FTBIN	ALLFT-L	Parse-σ	AllFT-R
(a) ju.ru.(ˈħuun)			**	**	
(b) (ˈju.ru).ħuun	*!			*	*
(c) (ˈju).ru.ħuun	*!	*!		**	**
(d) ju.(ˈru).ħuun	*!	*!	*	**	*
(e) (ˌju.ru).(ˈħuun)	*!		**		*

Note: the asterisk "*" indicates a violation of the constraint. "**" means that the candidate violates this constraint twice. The exclamation mark "!" indicates the violation that rules out the candidate. A candidate having more than one exclamation mark under two different constraints, means that these constraints are not ranked with respect to each other.

However, there is still an issue that ought to be addressed. The analysis so far is not well-equipped to correctly produce surface words with more than one heavy syllable. In the presence of more than one heavy syllable, the analysis falsely puts primary stress on the initial heavy syllable **Table 8(b)**.

In fact, the current metrical analysis predicts that both **Table 8(b)** with an initial stressed heavy syllable, and **Table 8(c)** with an initial secondarily stressed heavy syllable and a third syllable bearing primary stress, will outrank the actual surface form **Table 8(a)**, in which primary stress falls on the rightmost heavy syllable. Alnuqaydan (2023) solves this problem by introducing ALIGN (ˈσμμ R, wd, R), an alignment constraint that targets only stressed heavy syllables. It is a gradient constraint that requires the right edge of every stressed heavy syllable to be aligned with the right edge of the prosodic word. As **Table 9** shows, this new constraint must outrank ALLFT-L in order to assure that primary stress falls on the rightmost heavy syllable.

Table 8. Problematic Words with More than One Heavy Syllable.

/id͡ʒriħijhum/	SWP	FTBIN	ALLFT-L	PARSE-σ	AllFT-R
(a) id͡ʒ.ri.(ˈħij).hum			*!*	***	*
(b) (ˈid͡ʒ).ri.ħij.hum				***	***
(c) (ˌid͡ʒ).ri.(ˈħij).hum			*!*	**	****
(d) (ˈid͡ʒ.ri).ħij.hum		*!		**	**
(e) id͡ʒ.ri.(ˈħij.hum)		*!	**	**	
(f) id͡ʒ.(ˈri).ħij.hum	*!	*!	*	***	**
(g) id͡ʒ.ri.ħij.(ˈhum)	*!	*!	***	***	

Note: the asterisk "*" indicates a violation of the constraint. "**" means that the candidate violates this constraint twice. The exclamation mark "!" indicates the violation that rules out the candidate. A candidate having more than one exclamation mark under two different constraints, means that these constraints are not ranked with respect to each other.

Table 9. Words with More than One Heavy Syllable (Solved).

/id͡ʒriħijhum/	SWP	FTBIN	ALIGN (ˈσμμ R, wd, R)	ALLFT-L	Parse-σ	AllFT-R
(a) id͡ʒ.ri.(ˈħij).hum			*	**	***	*
(b) (ˈid͡ʒ).ri.ħij.hum			**!*		***	***
(c) (ˌid͡ʒ).ri.(ˈħij).hum			**!**	**	**	****

Note: the asterisk "*" indicates a violation of the constraint. "**" means that the candidate violates this constraint twice. The exclamation mark "!" indicates the violation that rules out the candidate. A candidate having more than one exclamation mark under two different constraints, means that these constraints are not ranked with respect to each other.

Having developed a complete metrical account of the QA stress system, we are ready to address the optionality problem.

4. The Account

This section is devoted to answering the two research questions stated in the introduction. To recapitulate, older QA speakers show variation in syllable structure when vowel-initial suffixes attach to verbs of the shape /(C)VC.C**V**C/. The second underlying vowel can occur either in its underlying position [ˈ(C)VC.C**V**.CVC] or in a metathesized position [(C)V.ˈC**V**C.CVC]. Examples are repeated in **Table 10**.

Table 10. QA Older Speakers' Variation.

Underlying Representation	Variant 1	Variant 2	Meaning
a./jatbə̲ʕ+uh/	[ja.ˈtə̲b.ʕuh]	[ˈjat.bə̲.ʕuh]	'he follows him'
b./jasmə̲ħ+en/	[ja.ˈsə̲m.ħen]	[ˈjas.mə̲.ħen]	'they allow/permit'
c./ikrə̲m+ah/	[i.ˈkə̲r.mah]	[ˈik.rə̲.mah]	'be generous with her'
d./itˢʕə̲m+uh/	[i.ˈtˢə̲ʕ.muh]	[ˈitˢ. ʕə̲.muh]	'feed him'
e./nagrə̲sˢ+ah/	[na.ˈgə̲r.sˢah]	[ˈnag.rə̲.sˢah]	'we sting her'

I argue that this is a metathesis process. This view assumes that the vowel in question is underlyingly present in the base form of the verb.

Prior to running the data against the present metrical account, there are important points that need to be set straight. Syncope, as a phonological process affecting syllable structure in different Arabic varieties, has been the subject of extensive research [10–12,18–26]. Generally speaking, short unstressed vowels in non-final open syllables often undergo syncope. This process creates onset clusters in QA, e.g. /ˈʃa.ʤar-uh/ → /ˈʃa.ʤa.ruh/ → [ˈʃʤa.ruh] 'his tree' [12]. There will not be detailed discussion on the domain of application of syncope in Arabic as it is beyond the scope of this paper (interested readers are referred to the aforementioned studies).

Table 11 shows that syncope fails to apply to the second unstressed short vowel in the medial syllable when a /CVC.CVC/ word is followed by a vowel-initial suffix / CVC.C**V**.CVC/, even though this environment would normally trigger syncope.

Table 11. Syncope Failure to Apply.

Underlying Representation	Surface Representation	Meaning
➔a) /ˈjak.tib-uh/	[ˈjak.ti.buh] / *[ˈjakt.buh] †	'he writes it/him (m. sg.)' [12]
(b) /ˈtar.sim-uh/	[ˈtar.si.muh]/ *[ˈtars.muh]	'she draws it (m.sg.)' [12]
(c) /ˈjasʔ.lə.ħuh/	[ˈjasʔ.lə.ħuh]/ *[ˈjasʔl.ħuh]	'(may) god/he guides him'

† In **Table 11(a)** and **Table 11(b)**, the suffix's vowel has been changed from [a] in [12] to [u] to conform to QA pronoun system. The asterisk "*" in **Table 11** indicates that the form is unattested.

According to Al-Mozainy [10], Al-Mohanna [11], and Alqahtani [12], syncope does not occur in these examples because it would result in a non-final CVCC which is disfavored in most Arabic varieties.

Adding to this typology, the faithful variant in our data [ˈjat.bə̲.ʕuh] 'he follows him' **Table 10(a)**, where stress falls on the initial heavy syllable, contains a short unstressed vowel occurring in a non-final open syllable. What blocks syncope in these faithful variants is not avoidance of non-final CVCC, as suggested by the aforementioned researchers. As above shown in the examples illustrating how the QA stress system functions, CVCC can occur word-medially (e.g. d͡ʒa.ˈraħt.wah 'you (mpl) hurt it/her') as well as word-initially (e.g. [ˈgist.wah] 'you (mpl) measured it/her'). Rather, syncope is blocked by avoidance of word-internal CCC clusters, as the medial vowel deletion would create this illicit cluster [6]. Triconsonantal clusters violate Alnuqaydan's [6] *CC[+cons], an undominated constraint in QA that militats against three consecutive [+cons] segments. We now test the optional data against the metrical analysis in **Table 12**.

The suboptimal Candidates **Table 12(c)–Table 12(j)**, with all the different foot configurations and stress placements, are ruled out by SWP and/or FTBIN. Candidate **Table 12(k)**, on the other hand, deletes the short unstressed vowel in a non-final position, thus incurring a fatal violation of the undominated *CC[+cons].

Table 12. Older QA Speakers' Optionality: Suffixation to Verb Base Approach.

/jatbəʕuh/	*CC[+cons]	SWP	FTBIN	Align (ˈσμμ R, wd, R)	AllFT-L	Parse-σ	AllFT-R
(a) ja.(ˈtə̲b).ʕuh				*	*	**	*
(b) (ˈjat).bə̲.ʕuh				**!		**	**
(c) (ˈja).tə̲b.ʕuh		*!	*!			**	**
(d) jat.(ˈbə̲).ʕuh		*!	*!		*	**	*
(e) ja.tə̲b.(ˈʕuh)		*!	*!		**	**	
(f) jat.bə̲.(ˈʕuh)		*!	*!		**	**	
(g) ja.(ˈtə̲b.ʕuh)			*!	*	*	*	
(h) jat.(ˈbə̲.ʕuh)		*!			*	*	
(i) (ˈja.təb).ʕuh		*!	*!			*	*
(j) (ˈjat.bə).ʕuh			*!	**		*	*
(k) (ˈjatb).ʕuh	*!			*		*	*

Note: the asterisk "*" indicates a violation of the constraint. "**" means that the candidate violates this constraint twice. The exclamation mark "!" indicates the violation that rules out the candidate. A candidate having more than one exclamation mark under two different constraints, means that these constraints are not ranked with respect to each other.

The metrical account only produces the unfaithful possible variant **Table 12(a)** where primary stress is placed closer to the right edge of the word. This variant undergoes vowel metathesizes to better satisfy Align (ˈσμμ R, wd, R). The other possible surface form (**Table 12b**) avoids metathesizing while still stressing the heavy syllable. The cost is a new violation of Align (ˈσμμ R, wd, R) because that heavy syllable is two syllables away from the right edge.

From an OT standpoint, the competition is clearly between the anti-metathesis faithfulness constraint Linearity

[9] and the markedness constraint ALIGN (ˈσμμ R, wd, R). Each possible form is governed by a different interaction between stress and metathesis. The metathesized form [ja.(ˈt̪əb).ʕuh] **Table 12(a)** is motivated by placing stress closer to the right edge of the word, whereas the faithful candidate [(ˈjat).bə̲.ʕuh] **Table 12(b)** is motivated by avoiding a faithfulness violation of LINEARITY. The following section tests which models of variation can capture this trade-off.

Standard OT is categorical in nature; it maps a single input to a single output. Phonological variation at the speaker level (intraspeaker variation) presents challenges for Standard OT because a single input can be mapped to mutiple grammatical outputs when more than one output is allowed to surface [1–3,27–30]. Numerous frameworks have been proposed to address this issue [1,2,4,5,27,31–38]. In this section, three optionality frameworks will be tested: PO [1–3], MaxEnt [4], and NHG [5]. As explained below, in PO, constraints are ranked, whereas in MaxEnt and NHG, constraints are weighted.

4.1. Partial Order Grammar (PO)

PO can produce more than one grammatical output for a single input by allowing variation in the ranking of competing constraints [1–3]. The indetermined part of the grammar is resolved differently across different evaluations. It is worth highlighting that due to the lack of quantitative data, the only logical question this paper attempts to answer in each variation model is whether it can produce only the attested surface outputs.

Section 4 established that the relevant constraints for the optionality in question are LINEARITY and ALIGN (ˈσμμ R, wd, R). By applying partial order to these two competing constraints, each output can surface. For space reasons, other suboptimal candidates are excluded form **Table 13**, as they violate the constraints shown in **Table 12**.

This tableau shows that each output can surface depending on how the partial ranking between the two competing constraints is resolved.

Table 13. Older QA Speakers' Optionality: PO.

/jatbəʕuh/	*CC[+cons]	SWP	FTBIN	ALIGN (ˈσμμ R, wd, R)	LINEARITY	ALLFT-L	Parse-σ	ALLFT-R
(a) ja.(ˈt̪əb).ʕuh				*	*(!)	*	**	*
(b) (ˈjat).bə̲.ʕuh				**(!)			**	**

Note: the asterisk "*" indicates a violation of the constraint. "**" means that the candidate violates this constraint twice. The exclamation mark "!" indicates the violation that rules out the candidate. A candidate having more than one exclamation mark under two different constraints, means that these constraints are not ranked with respect to each other.

4.2. Maximum Entropy (MaxEnt)

In MaxEnt, constraints are not ranked but rather weighted. The winning probability of a candidate is determined based on its harmony score. An output probability is assigned to each candidate independently in proportion to its harmony score. This mechanism makes this model probabilistic, thereby enabling it to produce variation [5,39].

The issue with probabilistic frameworks is that highly improbable candidates can occur with enough opportunities. Therefore, the error rate must be contained. Following Boersma and Hayes [32], illicit forms that surface at a rate of about 1 in 5000 (i.e. 0.02%) are considered indistinguishable from speech errors. In other words, these forms are accepted. For the analysis to be acceptable, the error rate must not be greater than 0.02%. This applies to both MaxEnt and NHG.

To be deemed successful, MaxEnt and NHG must be able to produce the actual surface forms for the QA stress system's inputs (i.e. no optionality; only one form is allowed to surface) as well as for inputs concerning the optional process. For the optional process, they seek a grammar that produces each of the two optional forms 50% of the time. All the candidates and their constraint violations (shown in **Appendix A**) were submitted to OTSoft 2.6 [40] for both MaxEnt and NHG, along with the respective settings: for MaxEnt, the number of iterations was 100,000; weight limits were set from 0 to 50; for NHG, grammar testing and form evaluation were each run 100,000 times;

initial plasticity was 1; final plasticity was 0.001; and all other options were unchecked.

MaxEnt successfully produced all and only the possible variants in the optional process (i.e. [ja.(ˈtə̲b).ʕuh] and [(ˈjat).bə̲.ʕuh]), each with a 50% predicted probability for each. The other suboptimal forms were never produced because they are all ruled out by either of the following constraints: SWP, FTBIN, *CC[+cons], or both. Two of these three constraints received the highest possible weight (i.e. 50), and the other one (i.e. SWP) was relatively assigned a high weight. See **Table 14**.

Table 14. Constraints' Weights: MaxEnt.

Constraint	Weight
FTBIN	50.000
SWP	21.348
*CC[+cons]	50.000
Align (ˈσμμ R, wd, R)	9.885
Linearity	3.538
AllFT-L	6.347
AllFT-R	0.000
Parse-σ	0.000

For inputs that include one heavy syllable, MaxEnt also accurately produced only the lone licit form: [ʃi.(ˈraħ).tah] . However, inputs that include more than one heavy syllable and those that include only light syllables were problematic. Following the error benchmark discussed earlier (i.e. 0.02%), MaxEnt failed to generate only the attested outputs for these inputs.

For inputs with more than one heavy syllable, the unattested form that assigns primary stress to the initial syllable *[(ˈid͡ʒ).ri.ħij.hum] received a predicted probability of 0.001, which is beyond the error rate that we agreed to accept (This calculation is as follows: 0.001 ÷ 1 × 100 = 0.1%, which exceeds our error benchmark of 0.02%.). The attested form [id͡ʒ.ri.(ˈħij).hum] received a predicted probability of 0.999 .

Likewise, for an input including only light syllables, the illicit form *[ɑ.(ˈsa.fan)], where primary stress falls on the second light syllable, received a unacceptable predicted probability of 0.002. The surface form [(ˈɑ.sa).fan] was only given a predicted probability of 0.998.

Unlike the optional data–where the unattested forms are eliminated by constraints that received high weights–these problematic categorical outputs are ruled out by other constraints that, by contrast, did not receive high weights.

Due to its inaccurate results in modelling the categorical stress data on which the account is built, it is concluded that MaxEnt is not as successful a framework as PO in accounting for the present paper's data.

4.3. Noisy Harmonic Grammar (NHG)

Like MaxEnt, constraints are weighted in Harmonic Grammar. The weighted sum of the candidates' violations determines the winners. NHG is different from MaxEnt in that noise is added to each constraint [5,32,41]. Weights are perturbed by noise, and the candidate that receives the best harmony score is the winner. Various candidates can surface, since the added noise is different on different evaluations.

NHG's performance on both the optional and categorical data was almost flawless. Starting with the optional data, each of the two possible optional forms (i.e., [ja.(ˈtə̲b).ʕuh] ~ [(ˈjat).bə̲.ʕuh]) was almost produced 50% of the time, with [ja.(ˈtə̲b).ʕuh] being produced 49.918% of the time and [(ˈjat).bə̲.ʕuh] being produced 50.075% of the time. The unattested candidates *[jat.(ˈbə̲.ʕuh)] and *[(ˈjatb).ʕuh] were produced three times and four times, respectively. Given our error threshold in relative to 100,000 trials per input (i.e., 1 in 5000), these anomalies cannot be distinguished from speech errors.

For the categorical data (i.e. inputs with only light syllables; inputs with only one heavy syllable, and inputs with

more than one heavy syllable), NHG approximately generated the sole possible output 100% of the time. The unattested candidate *[ʃi.(ˈraħ.tah)] was produced once for the input with only one heavy syllable /ʃiraħtah/, and the unattested candidate *[id͡ʒ.ri.(ˈħij.hum)] was produced once for the input with more than one heavy syllable /id͡ʒriħijhum/. Similarly, these are well below the adopted error benchmark.

The results indicate that NHG is compatible with the data in this study, as it was able to accurately model both the optional and categorical data. The weights that are assigned for each constraint are shown in **Table 15**.

Table 15. Constraints' Weights: NHG.

Constraint	Weight
FTBIN	9.000
SWP	32.000
*CC[+cons]	21.231
Align (ˈσμμ R, wd, R)	14.121
Linearity	7.648
AllFT-L	7.648
AllFT-R	1.121
Parse- Σ	0.000

5. Conclusions

The present paper's phonological optionality stems from an unsolved conflict in the grammar. Two constraints responsible for producing different outputs seem to be equally preferred. In the speech of younger QA speakers, on the other hand, the conflict is resolved invariably by placing Linearity, the constraint that favors the underlying candidate [(ˈjat).bə̲.ʕuh] over Align (ˈσμμ R, wd, R) the constraint that favors the metathesized candidate [ja.(ˈtə̲b).ʕuh].

From a sociolinguistic standpoint, the variation in the speech of older QA speakers might be regarded as the coexistence stage initially suggested by Labov's work [42,43]. In this stage, both the old variant and the new one coexist until one of them prevails and forces the other to disappear. In our case, it is not clear which variation is which.

The data of the present study add to the typology of Arabic varieties by showing an interesting case of interaction between phonological variation and stress parameters in an understudied Arabic variety. Unlike other analyses of phonological variation, the proposed analysis provides an actual justification of the phenomenon by linking it to broader grammatical components. The significance of the present study is also clearly manifested in the fact that it tests the cross-linguistic viability of pre-existing models of variation.

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Informed Consent Statement

Not Applicable.

Data Availability Statement

It is available upon request from the author.

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Conflicts of Interest

The author declares no conflicts of interest.

Appendix A

Table A1. OTSoft's Input.

	SWP	FTBIN	ALIGN (ˈσμμ R, wd, R)	LINEARITY	ALL-FT-L	PARSE-σ	ALL-FT-R	*CC [+cons]
/jatbəʕuh/								
→a) ja.(ˈt̲əb).ʕuh			*	*	*	**	*	
→b) (ˈjat).bə̲.ʕuh			**			**	**	
→c) (ˈja).t̲əb.ʕuh	*	*		*		**	**	
(d) jat.(ˈbə̲).ʕuh	*	*			*	**	*	
(e) ja.t̲əb.(ˈʕuh)	*	*		*	**	**		
(f) jat.bə̲.(ˈʕuh)	*	*			**	**		
(g) ja.(ˈt̲əb.ʕuh)		*	*	*	*	*		
(h) jat.(ˈbə̲.ʕuh)	*				*	*		
(i) (ˈja.təb).ʕuh	*	*		*		*	*	
(j) (ˈjat.bə).ʕuh		*	**			*	*	
(k) (ˈjatb).ʕuh			*			*	*	*
/ʃiraħtah/								
→a) ʃi.(ˈraħ).tah			*		*	**	*	
(b) (ˈʃi.raħ).tah	*	*				*	*	
(c) ʃi.(ˈraħ.tah)		*	*		*	*		
(d) (ˈʃi).raħ.tah	*	*				**	**	
(e) ʃi.raħ.(ˈtah)	*	*			**	**		
(f) (ˌʃi).(ˈraħ).tah	*	*	*		*	*	***	

Table A1.*Cont.*

	SWP	FTBIN	ALIGN (ˈσμμ R, wd, R)	LINEARITY	ALL-FT-L	PARSE-σ	ALL-FT-R	*CC [+cons]
/id͡ʒriħijhum/								
➔a) id͡ʒ.ri.(ˈħij).hum			*		**	***	*	
(b) (ˈid͡ʒ).ri.ħij.hum			***			***	***	
(c) (ˌid͡ʒ).ri.(ˈħij).hum			****		**	**	****	
(d) (ˈid͡ʒ.ri).ħij.hum		*	***			**	**	
(e) id͡ʒ.ri.(ˈħij.hum)		*	*		**	**		
(f) id͡ʒ.(ˈri).ħij.hum	*	*			*	***	**	
(g) id͡ʒ.ri.ħij.(ˈhum)	*	*			***	***		
/ɑsafan/								
➔a) (ˈɑ.sa).fan	*					*	*	
(b) ɑ.(ˈsa.fan)	*				*	*		
(c) (ˈɑ).sa.fan	*	*				**	**	
(d) ɑ.(ˈsa).fan	*	*			*	**	*	
(e) ɑ.sa.(ˈfan)	*	*			**	**		

Note: the asterisk "*" indicates a violation of the constraint. "**" means that the candidate violates this constraint twice. The exclamation mark "!" indicates the violation that rules out the candidate. A candidate having more than one exclamation mark under two different constraints, means that these constraints are not ranked with respect to each other.

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