Acoustic Correlates of Rhotic Emphasis in Fessi Spoken Arabic

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1. Background

1.1 Emphasis in Arabic Phonology

The consonantal feature known as ‘emphasis’ is among the most distinctive features of Arabic and other Semitic languages. It involves a secondary phonetic articulation, generally identified as pharyngealization, which characterizes emphatic consonant phonemes in opposition to their ‘plain’ counterparts and can also appear as a subphonemic property of other consonants and vowels. In Modern Standard Arabic (MSA), phonemically contrastive emphasis is restricted to coronal obstruents, with the exception of historical palatals /ʃ/ and /ʒ/. Thus, there is a phonemic contrast in MSA between /t d s ɵ/ and /ṭ ḍ ṣ ʒ̣/, but not between /b/ and /ḅ/ or /n/ and /ṇ/. While in MSA, there are two plain coronal obstruents (/θ/ and /ẓ/) which do not have emphatic counterparts, this asymmetry has been levelled out of most colloquials, including the Moroccan dialect. There, interdentals have merged with alveolar stops and a phonemic /ẓ/ has become established, yielding a one-to-one correspondence between the set of coronal obstruents and the articulatory range of unambiguously phonemic emphasis. In what follows, these contrastively emphatic coronal obstruents /ṭ ḍ ṣ ʒ̣/ will be referred to as the ‘primary emphatics’ of Moroccan Arabic.

In contrast to primary emphasis, secondary emphasis is a subphonemic property of segments which are not underlyingly pharyngealized. When the pharyngealization associated with emphasis spreads to nearby segments, it causes secondarily pharyngealized variants of both vowels and consonants. The emphatic allophones of vowels are also characterized by changes in tongue body position, which vary by dialect; in Morocco, these may be described roughly as [ɑ] for /a/, [i] for /i/, and [o] for /u/ (Heath 1987). While emphasis spread has different properties in different dialects, it is ubiquitous in Arabic; in most of Morocco, spreading extends to all
segments within a word and is only clearly blocked by inflectional morpheme boundaries. (Heath 1987; Dell & Elmedlaoui 2002).

3 The focus of this paper is a third category of emphatic-like consonants, neither clearly primary nor clearly secondary, which I call 'marginal emphatics'. Marginal emphatics do not acquire pharyngealization from feature spreading, yet are not unambiguously in categorical contrast with their plain counterparts; their characteristic secondary articulation may also have different phonetic properties to the articulation of primary emphatics. In Moroccan Arabic, [ɾ], [ḷ], [ḅ], [f̣], and [ṃ] may all be considered marginal emphatics, and the uvular stop /q/ also exhibits some emphatic-like qualities. Since the marginal emphatic labials are mostly restricted to loanwords and intersect with the structurally complex and unrelated issue of labialization, and the marginal emphatic /l/ has an extremely limited distribution, I am restricting my attention here to the behavior of [ɾ] and its interaction with /q/.

4 The existence of [ɾ] outside of secondary emphatic contexts is historically due to a separate phonological process by which /r/ is pronounced with pharyngealization except when adjacent to a front vowel (Younes 1994). While this rule has been preserved in some dialects of Arabic, in Morocco reduction of the vowel system and a tendency towards paradigm regularization has resulted in a shift towards a lexical distribution of rhotic emphasis. The structure of the resulting system is poorly understood, with the ‘quasi-phoneme’ /ɾ/ being favored in certain phonetic environments over others and reportedly triggering a ‘weaker’ variant of emphasis spread. This paper offers preliminary quantitative data on rhotic pharyngealization among Moroccan speakers in the city of Fès, which suggest that [ɾ] may indeed be a distinct phoneme, causing uvularization, if not pharyngealization, of adjacent vowels.

1.2 Quantifying Marginal Emphasis

5 The clearest acoustic correlates of pharyngealization and uvularization in sonorants are lowering of the second formant (F2) and raising of the first formant (F1) (Al-Masri & Jongmann 2004, Bin-Muqbil 2006). This makes it quite easy to measure emphasis spread quantitatively, and to use the pronunciation of adjacent vowels to determining whether a consonant is emphatic. Differences in frequency shift patterns can also be used to contrast different classes of conditioned pharyngealization – in this case, to distinguish intermediate effects associated with marginal emphatics from canonical emphasis spread.

6 The questions answerable with this acoustic toolkit relate to phonemicization and feature mapping, which are central to structural models of the organization of speech sounds. If conflicting evidence exists for the phonological status of [ɾ], how do individual speakers learn to organize the segment in their grammar? What feature serves to distinguish it from [ɾ] – the existing emphatic feature, or a new category with different phonological effects? Is there in fact a difference between marginal and primary emphatics, and, if so, what is it?

7 In this paper I seek to address these questions quantitatively, by investigating the distribution of [ɾ] through the phonetics of adjacent vowels to determine its phonemic status, and by comparing its phonetic effects to those of uvular stops and primary emphatics to assess their phonological similarity. Even though the initial results presented here may only scratch the surface of the problem, they demonstrate what
quantitative data analysis can contribute to the resolution of phonological problems that have traditionally been addressed through qualitative descriptive work in Arabic dialectology.

2. Methodology

I collected a dataset for analysis by recording a corpus of native Moroccan Arabic speech, targeting emphasis spread and rhotic emphasis. During fieldwork, I administered a standardized interview targeting free speech and wordlists to 24 participants, with the help of native-speaker assistants. Post-collection, data were first manually transcribed and segmented, and raw formant measures were extracted from segments using Praat (Boersma & Weenink 2017). The resulting values were checked and iteratively recalculated to remove false measurements, and then normalized using the Lobanov technique (Adank et al. 2004). More details concerning data collection follow below.

2.1 Subject Recruitment and Demographics

I conducted my interviews over the course of a five-month stay in Morocco, with logistical assistance from the American Language Center-Fès. Both my interview assistants and the majority of my participants were recruited through existing networks between students, teachers, and staff at the center, a method which is reflected in the demographics of my speaker sample. Of my 24 participants, 8 were Moroccan university students studying English at the ALC and another 8 worked as language teachers at the school. 5 more were employed by the center as administrative or maintenance staff, and the remaining 3 were referred to me by contacts within the center. As a result, my speaker sample reflects individuals associated with a more affluent, Western-educated sector of Fessi society, even while including some individuals of a more traditional social background.

Though this sample of Fessi society skews young, male, and well-educated, it still provides sufficient diversity to control for gender, age, and class. Class was evaluated indirectly through neighborhood of residence, educational level, and occupation. Individuals who had received some higher education were classed as upper class, while individuals who had received less than a fifth-grade education and held jobs involving manual labor were judged to be lower class. Table 1 charts the makeup of my participant sample by age group, sex, and social class.

Table 1. Distribution of Participants by Age, Sex, and Social Class

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 18-25</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Age 26-40</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Age 40+</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Social Class</td>
<td>Upper</td>
<td>Lower</td>
</tr>
<tr>
<td>Upper</td>
<td>4</td>
<td>---</td>
</tr>
<tr>
<td>Lower</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>
I also considered whether each participant had been born in Fès, and if not, how long they had resided there. In general, I admitted anyone who had moved to Fès as a child or adolescent into the study, but not individuals who had relocated to the city from another part of Morocco as an adult. 16 of my 24 speakers were lifelong Fessi native speakers of Arabic, and the rest had long-standing membership in the speech community.

2.2 Interview and Wordlist Structure

This paper addresses data drawn from the final elicitation portion of each interview. This segment lasted between fifteen and thirty minutes, and involved responses to two written wordlist prompts presented in Arabic script. The first list consisted of 86 words designed to ensure elicitation of a comprehensive vowel tokens in as many phonetic contexts as possible. The second list of 60 words targeted specific vocabulary items reported to exhibit marginal emphatics, as well as control words differing minimally from the targets. For certain words, plural or diminutive forms were elicited.

The wordlists were followed by a short reading passage and, finally, a list of five homophone pairs contextualized in sentence frames, reported to exhibit a minimal contrast between [ṛ] and [r] by Hilili (1979). I found that most of these words were considered archaic or marginal by my participants.

3. Results

The results presented here are preliminary, and explore the behavior of my Fessi speaker sample in aggregate. They confirm the structural ambiguities reported in earlier work through quantitative phonetic measurements, and also suggest an explanation that will require further analysis to confirm. I focus on F1 and F2 differences across selected paradigms and phonological contexts. The data generally support the view that [ṛ] is a separate phoneme with an ‘emphatic’ feature that is distinguishable from primary emphasis, and has some phonetic similarity to the uvularization associated with /q/. They also, however, indicate that restricted phonetic conditioning perseveres in lexically specific contexts.

Two intentional restrictions on the analysis should be kept in mind. First, I only use measurements from the vowels /a/ and /i/, since these vowels exhibit the most robust emphasis-related differences in both the first and second formants, and tend to be long enough to allow for reliable steady-state measures at the midpoint. Second, I make no a priori determinations of rhotic emphasis prior to analysis, but instead begin by evaluating all rhotics together and consider patterns of emphasis contrast as acoustic evidence emerges for them.

3.1 General Distribution of Vowel Variants

I established general patterns of emphasis spread by calculating formant means and ranges for normalized midpoints of /a/ and /i/ in monosyllables with emphatic coronal obstruents (EMPH), rhotics (R), uvular stops (Q), and plain coronal obstruents (COR), respectively (Figure 1). The contexts are ordered from lowest to highest mean frequency in each plot. It is evident that vowels near primary emphatics have
uniformly lower F2 and higher F1 than vowels near primary coronals, and that in general, vowel frequencies associated with /r/ and /q/ lie somewhere in between those two extremes. The only exception to this last statement is the exceptionally high mean F1 of /a/ adjacent to /r/, which was not, however, found to be statistically significant from /a/ adjacent to either /q/ or the emphatic coronals according to a t-test analysis. Almost all other two-way intergroup comparisons, however, were found to be significantly different from each other.1

Figure 1. Formant Ranges of /a/ and /i/ by phonetic context.

One notable result from this aggregated comparison is that the respective effects of primary emphatics, /r/, and /q/ on the midpoint of the following vowel are all phonetically distinct. It cannot be said that /r/ conditions the same allophone of /a/ as /q/ or /t/ does, or even that a coarticulatory effect from uvularization applies uniformly to vowels after /r/ and /q/. Another important consequence of this data is that the simple allophonic hypothesis must be discarded: /i/ after /r/ does not belong to the same distribution as /i/ after a plain coronal, and /a/ after /r/ does not belong to the same distribution as /a/ after a primary emphatic. The phonological situation, then, cannot be described by phonetic conditioning alone.

3.2 Emphasis spread to following /a/

For more detailed data on consonant effects, I considered sets of words differing minimally from each other in which a vowel was immediately preceded by a conditioning consonant from each class. For /a/, I used the minimal quadruplet /tas, qas, ras, and kas/, with F2 frequency distributions as shown in Figure 2. In this set we see that /a/ in ras is close to, if not identical with, the emphatic /a/ in tas, while qas is intermediate and /k/, the plain consonant, is next to the frontest vowel.
A closer look, however, reveals that speakers are split on the pronunciation of qas, with some opting for a front [a] and others producing the emphatic allophone [æ]. No such bimodal split operates on ras – all speakers produce this word as [ɾæs], with the emphatic allophone of the vowel. Figure 3 is a scatterplot of individual datapoints highlighting this split. 7 speakers produced [a] after /q/, 13 speakers had [æ] after /q/, and 3 speakers produced both variants.

These data suggest that the intermediate formant values of /q/ which we saw in the aggregated data may be due at least in part to a bimodal distribution. While the same may turn out to be true for /ɾ/, in this particular word all speakers agree that [ɾ] is the appropriate variant, and its F2 effect on the following vowel is quite similar to the effect of /t/ in tas ($t(143)=0.385$, $p=0.70$). This comparison, then, is instructive with regards to /q/, and also shows that [ɾ] is closely allied to primary emphatics as pronounced in some words.
3.3 Emphasis Spread to following /i/

Repeating this exercise with /i/ directly following consonants of different classes, we next compare the midpoint of the /i/ vowel in ṭisan, rib, baqi, and tis. These words do not form a minimal quadruplet, but are the best sample for comparison in this context that could be extracted from the wordlist.

Figure 4 compares the F2 means and ranges among these four words. The clearest indication is that /q/ patterns with non-emphatics with respect to F2 of /i/, with no significant difference between baqi and tis (|t|(127)=0.98, p=0.33). There is, however, a significant difference in F1 (|t|(107)=10.1, p<0.001), with means of 449 Hz and 339 Hz respectively. /i/ in ṭisan has a markedly lower F2 than either of these, and a correspondingly higher F1 centered around 508 Hz. /i/ in rib, on the other hand, has a widely scattered range of F2 values, possibly suggesting a bimodal distribution such as we saw for /a/ in qas above.
In Figure 5, we see a scatterplot of these tokens in the F1-F2 vowelspace. Two distinct clusters for tis and tisan are clearly visible, as well as the lowered F1 of /i/ in baqi in a cluster which overlaps with tis on the F2 dimension. The /i/ in rib, however, is quite diffuse, and does not clearly overlap with any of the other three distributions.

Unfortunately, the parameters of a possible rib/rib distinction are difficult to discern from this data. This item was one of Hilili’s archaic minimal pairs, and the reported emphatic lexeme, meaning ‘fall apart, deteriorate’, was rejected by many speakers. The lexical item with the plain variant, ‘curdle’, was more accessible, but often altered to past tense rayeb by participants (those tokens are not presented here). A t-test comparison of rib ‘deteriorate’ and rib ‘curdle’ reveals a significant difference in F2 but
not in F1, but even so the distributions overlap extensively, are quite diffuse, and do not pattern closely with the other distributions.

3.4 The minimal pair birān/biran

The strongest evidence found so far in the data for a phonemic split between [r] and [ɾ] is the existence of a minimal pair birān ‘bars’/ biran ‘wells’ in the speech of many participants. This pair was not previously attested, as biran appears to be a novel plural form of bir ‘well’, placing it in minimal opposition to the plural birān of the French loanword bar. Since in both paradigms, the plain or emphatic rhotic is preserved as part of the root, this is a strong indication that an underlying contrast exists between /r/ and /ɾ/.

Comparisons of formant values between birān and biran confirm that the difference between the two asserted by speakers has a phonetic basis. Table 2 gives mean formant values and interword t-test comparisons across all speakers who had the minimal pair. For comparison, the mean formant values of /i/ were 494 Hz (F1) and 2107 Hz (F2) adjacent to primary emphatics and 382 Hz (F1) and 2381 Hz (F2) adjacent to plain coronals, and those of /a/ were 742 Hz (F1) and 1340 Hz (F2) adjacent to primary emphatics and 660 Hz (F1) and 1582 Hz (F2) adjacent to plain coronals.

Table 2. Formant comparisons for the biran/biran minimal pair.

<table>
<thead>
<tr>
<th>Vowel</th>
<th>Formant</th>
<th>mean for birān</th>
<th>mean for biran</th>
<th>t-test result</th>
</tr>
</thead>
<tbody>
<tr>
<td>/i/</td>
<td>F1</td>
<td>528 Hz</td>
<td>463 Hz</td>
<td>t(97) = 4.75, p &lt; 0.001**</td>
</tr>
<tr>
<td></td>
<td>F2</td>
<td>1994 Hz</td>
<td>2116 Hz</td>
<td>t(82) = 3.46, p &lt; 0.001**</td>
</tr>
<tr>
<td>/a/</td>
<td>F1</td>
<td>781 Hz</td>
<td>706 Hz</td>
<td>t(90) = 3.75, p &lt; 0.001**</td>
</tr>
<tr>
<td></td>
<td>F2</td>
<td>1411 Hz</td>
<td>1599 Hz</td>
<td>t(100) = 5.02, p &lt; 0.001**</td>
</tr>
</tbody>
</table>

A further aspect of this alternation which is of structural interest is the lack of a significant difference in the pronunciation of the vowels in biran ‘bars’ between speakers who used the biran plural for ‘wells’ and speakers who used a different form such as byur or byar. This result reinforces the conclusion that phonetic differences between biran and biran are not merely due to functional dissimilation.

3.5 The alternating paradigm ḥmar/ḥmir

While the biran/birān contrast provides data in favor of categorical rhotic emphasis, there is also some evidence for allophonic alternation. Perhaps the clearest example of this is the paradigm ḥmar/ḥmir ‘donkey (sg./pl.)’. With respect to F2 effects, shown in Table 3, speakers consistently produced this pair with an emphatic-like variant of a in the singular and a plain variant of i in the plural, conforming to the distributional generalization that /ɾ/ should be de-emphaticized when adjacent to a front vowel, but should be emphatic elsewhere.
Table 3. F2 comparisons for ħmar/ḥmir

<table>
<thead>
<tr>
<th>Vowel</th>
<th>Condition</th>
<th>Mean frequency</th>
<th>t-test comparison with ‘donkey’</th>
</tr>
</thead>
<tbody>
<tr>
<td>/a/</td>
<td>plain /a/</td>
<td>1584 Hz</td>
<td>(</td>
</tr>
<tr>
<td></td>
<td>emphatic /a/</td>
<td>1341 Hz</td>
<td>(</td>
</tr>
<tr>
<td>/i/</td>
<td>plain /i/</td>
<td>2362 Hz</td>
<td>(</td>
</tr>
<tr>
<td></td>
<td>emphatic /i/</td>
<td>2106 Hz</td>
<td>(</td>
</tr>
</tbody>
</table>

5. Conclusions and Further Directions

Considering the vowel comparisons and morphological paradigms presented above, we see the analytical difficulties presented by marginal emphasis well represented in the acoustic data. Rhotics pattern with emphatics in some words and trigger intermediate pharyngealization spread in others; only in the isolated plural form ħmir do we see /r/ conditioning the plain allophone of a vowel. /q/, on the other hand, varies between plain and emphatic pronunciations, as some speakers associate it with weak pharyngealization of neighboring vowels and others do not. Previously attested minimal pairs differentiating /r/ and /ṛ/ have gone out of use, while new ones have emerged to take their place.

Even so, the use of quantitative acoustic data allows a precision of description that will allow for resolution of these difficulties in time, and offers testable, reproducible data that do not rely on the judgments of individual researchers. Native speakers, influenced by orthography or traditional grammatical analyses, often have contradictory intuitions with respect to marginal emphatics, and the true complexity of the situation is best captured by direct analysis of the speech signal itself.

In the next stages of research, individual speakers’ patterns of emphasis spread will be compared, and a wider variety of individual vocabulary items will be tested for the behavior of /r/ and /q/. Free speech recordings will be drawn upon to help fill gaps in the data, and evidence from non-adjacent vowels will be used to test the coarticulatory nature of intermediate levels of emphasis spread. The end result will, I hope, provide conclusive answers to outstanding questions on ‘quasi-phonemes’ in Arabic, and further demonstrate the value of acoustic data to phonological research.
BIBLIOGRAPHY


NOTES

1. Consonantal emphasis is distinct from the pharyngeal articulation of [ʕ] and [ħ], which exhibit constriction in the lower pharynx. Emphatics are instead characterized by upper pharyngeal and/or uvular constriction (Sylak-Glassman 2014; Ghazeli 1977; Zawaydeh & de Jong 2011).

2. This list was largely drawn from a pre-publication copy of the Georgetown University Dictionary of Moroccan Arabic (Maamouri 2016).

3. The only exception in this respect was the Q/COR contrast for F2 of /i/.

4. No significant formant effect of adjacency to a labial consonant was found in these contexts.

5. T-test results for these comparisons were as follows: F1 of /a/: |t|(66)=0.41, p=0.68; F2 of /a/; |t| (84)=0.23, p=0.82; F1 of /i/; |t|(67)=1.00, p=0.32; F2 of /i/; |t|(54)=1.58, p=0.12.

6. F1 comparisons, however, found the vowel distributions in hmar/hmir to be distinct from both plain and emphatic distributions. This situation is reminiscent of the raised F1 in vowels adjacent to /q/ discussed above, but may simply be a relic of the data structure. Given the large number of datapoints and the unequal sample sizes in many of these t-test comparisons, I judge a lack of significant difference between two distributions – as found in the F2 tests here – to be a much more noteworthy finding.

ABSTRACTS

This paper considers the phonological patterning of pharyngealised /ɾ/ in a dialect of Moroccan Arabic. Through acoustic analysis of recorded interviews targeting specific vocabulary and morphological paradigms, I describe a marginally contrastive distribution of emphatic and plain rhotic variants among Arabic speakers in Fès, indicating that pharyngealised variants trigger a process similar to, but distinct from, the emphasis spread associated with the canonical emphatic consonants /ṭ/, /ḍ/, and /ṣ/. While in some varieties of Arabic, rhotic pharyngealisation is an allophonic alternation conditioned by adjacent back vowels, in others [ɾ] has spread through morphological and lexical diffusion to attain quasi-phonemic status. In the changing urban dialect of Fès, the presence of conflicting dialect norms allows us to study how individuals resolve ambiguous phonological input with respect to /ɾ/, and how this is manifested in their phonetic output.

For this study, I conducted 24 mixed sociolinguistic/phonetic interviews, with the help of native Fessi interview assistants. The interviews provide a comprehensive sample of rhotics for each speaker, which were analyzed for their phonetic effects on adjacent vowels. The acoustic data indicate a wide range of individual variability in the patterning of emphatic /ɾ/, tempered by predictable patterns in certain paradigms such as hmar ‘donkey’ with non-emphatic plural hmir, or the minimal contrast between biran ‘bars’ and biran ‘wells’. Speakers also exhibited variability in the scope of pharyngealisation spread from /ɾ/, even though all speakers exhibited predictable long-range spread from /ɾ/, /ṣ/, and /ḍ/. These results point to a phonological change in progress, moving in the direction of phonemic pharyngealized /ɾ/.
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**Keywords:** emphasis, rhotics, pharyngealization, phonology, Morocco, phonemicization, levelling

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