EPENTHETIC AND EXCRESCENT VOWELS IN STOP SEQUENCES IN TRIPOLITANIAN LIBYAN ARABIC

Barry Heselwood, Abdurraouf Shitaw, Aimen Ghummed, Leendert Plug

University of Leeds
b.c.heselwood@leeds.ac.uk

ABSTRACT

We report on an investigation of inter-consonantal intervals (ICIs) in sequences of two, three and four stops within and across word boundaries in Tripolitanian Libyan Arabic (TLA). This variety of Arabic has been described as allowing vowel epenthesis in all consonant clusters [7]. Our investigation was motivated by the question of whether some of the 'epenthetic vowels' of TLA are better characterized as 'excrescent vowels', following the distinction made by [5]. To answer this question, we analysed ICI durations at normal and fast speaking rates across permissible stop sequences within and across word boundaries. We also investigated the relationship between ICI duration and voicing. Our results are consistent with the observations presented in [7], but show that there is indeed evidence for the existence of both epenthetic and excrescent vowels in TLA.

Keywords: Stop sequences, epenthesis, voice assimilation, Tripolitanian Libyan Arabic.

1. INTRODUCTION

There is now a considerable body of research literature on the gestural organisation of speech, much of it cast in the framework of Articulatory Phonology [2].A key point of interest in stop sequences is the relative timing of the gestures, in particular whether they overlap such that the gesture for C2 reaches closure before C1 is released. If it does not, then there is a short period between the two stops when the vocal tract is open during which time there may be discernible vocalic segments of various kinds which we shall refer to generically as Inter-Consonantal Intervals (ICIs).

Some ICIs may simply be a consequence of the release of C1, being very brief and arising due to vocal tract mechanics and aerodynamics, while others may exhibit characteristics of a true vowel by having distinct formants and longer durations. [5] calls the first type 'excrescent vowels' and the second type 'epenthetic vowels'. The latter differ from lexical vowels in being predictable and therefore phonologically redundant. They are, however, said to be required by the phonology in order to prevent phonotactic violations. In this paper, we show that there is evidence for the occurrence of both epenthetic and excrescent vowels in Tripolitanian Libyan Arabic (TLA).

TLA is the dialect of Arabic spoken in Tripoli, the capital city of Libya situated in the west of the country with a population of about two million. Clusters of two oral stop consonants are found in syllable onsets and in syllable codas. Some clusters contain stops which agree in voicing, e.g. /gdar/ 'he was able', /hatk/ 'violation', but examples such as /gtal/ 'he killed' and /fatg/ 'hernia' show that stops in a TLA cluster do not have to agree in voicing. Across word boundaries, TLA phonotactics thus allow sequences of up to four stops:-VC#CV-, -VCC#CV-, -VC#CCV- and -VCC#CCV-.

[7] describes TLA as a 'VC' dialect in [6]'s classification of Arabic dialects, since in sequences of three consonants, epenthesis occurs in front of the middle consonant: -VC*v*C#CV- and -VC*v*#CCV-, where '*v*' signifies an epenthetic vowel. In other Arabic dialects an epenthetic vowel occurs after the middle consonant ('CV' dialect), or no epenthesis occurs ('C' dialects). [7: 345] observes that all permissible consonant clusters in TLA may in fact be broken up by epenthesis, and epenthesis patterns are subject to inter- and intra-speaker variation. This raises the question of whether some of the 'epenthetic vowels' of TLA may be better characterized as excrescent vowels. We suggest that this is indeed the case, but confirm the classification of TLA as a 'VC' dialect.

2. DATA AND METHOD

2.1. Data

Four male native speakers of TLA produced phrases containing sequences of two stops within words (1a. and b.). Two of those speakers plus two more produced phrases with two, three and four stops across word boundaries (c. to f.) containing all attested non-homorganic combinations of /t/, /d/, /k/ and /g/. (1) presents examples:

(1)	a.	##CCV-	/ktab/ 'he wrote
	b.	-VCC##	/hatk/ 'violation'
	c.	-VC#CV-	/dag#tal/ 'dig a wire'
	d.	-VC#CCV-	/fak#tkasir/ 'jaw broke'

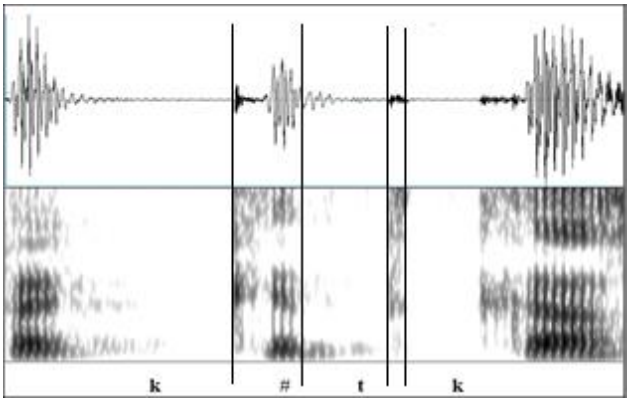
e. -VCC#CV- /ʕagd#kam/ ‘how much tying’
f. -VCC#CCV- /ʕagd#ktab/ ‘a book knot’

The phrases in (1a) and (1b) were produced in isolation to elicit utterance-initial and final clusters. All other phrases were embedded in the carrier sentence ‘/ma tguli:ʃ/__’ ‘Do not say __’. There were six phrases of each sequence type, repeated three times at normal speech rate and three times at fast rate. This design yielded a total of 1248 tokens.

2.2. Acoustic analysis

For each sequence of two stops, we quantified ICI duration by measuring between the offset of the hold phase of C1 and the onset of the hold phase of C2. Under this method, positive ICIs include burst releases and aspiration as well as voiced vocalic segments, as seen in Fig. 1, while zero ICIs correspond to stop sequences in which the first stop is unreleased. We coded the ICI and the stops making up each sequence for voicing.

Figure 1: Spectrogram and waveform illustrating ICI measurements in /fak#tkasir/ ‘jaw broke’. The vertical lines delimit the two ICIs.



2.3. Hypotheses

Our quantitative analysis tested a number of specific hypotheses, each of which follows from the general hypothesis that epenthesis in TLA involves both epenthetic and excrescent vowels as defined by [5].

H1: ICI durations are not normally distributed. Since excrescent vowels are shorter than epenthetic vowels, the presence of both should result in evidence of bimodality.

H2: ICI durations are affected by a speech rate increase in two distinct ways. If excrescent vowels arise from vocal tract mechanics in getting from one consonant to another, while epenthetic vowels are similar to lexical vowels, the latter might be more prone to decreasing in duration as tempo increases.

H3: ICI durations are systematically related to epenthesis site. This follows from the expectation that the ‘epenthetic vowels’ in -VC*v*C#CV- and-VC#C*v*CV-are indeed ‘epenthetic’, while those that occur variably in other contexts according to [7] may deserve the label ‘excrescent’.

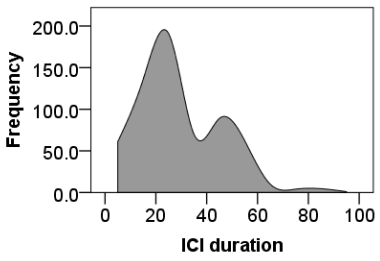
H4: ICI durations are systematically related to ICI voicing and the voicing of surrounding consonants. Epenthetic vowels are generally described as voiced, while excrescent vowels may be voiceless in the context of voiceless consonants [4: 1585]. In the latter case, the ‘excrescent vowel’ is effectively equivalent to the burst release of the first consonant: a brief period of vocal tract openness which can give rise to a ‘vowel-like percept’ [5: 1585]. Therefore, we would expect short ICIs to be more prone to voicelessness than long ICIs, in particular in the context of voiceless consonants.

3. RESULTS

3.1. ICI duration

Given that excrescent vowels are generally shorter than epenthetic vowels, the presence of both in a single dataset should result in evidence of bimodality in the distribution of ICI durations. As seen in Fig. 2, our data are consistent with this hypothesis. The distribution of ICI durations is significantly different from normal (Shapiro-Wilk: $W=0.972$, $df=624$, $p<0.001$), and clearly contains two main peaks: about 60% of ICIs are below 35ms, with a mean around 20ms, and about 40% are above 35ms, with a mean around 50ms.The distribution includes 21 zero ICIs (3%). At first sight, it would seem reasonable to conclude that we are looking at the conflation of two distributions here, each of which approaches normality: one for one type of ICI, and one for another.

Figure 2: Distribution of ICI durations (in ms) at normal speech rate.

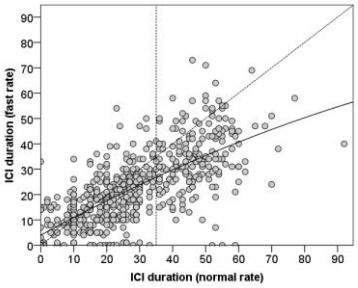


3.2. Effect of speech rate increase

The general trend in our data is for ICI durations to be lowered by a speech rate increase: in Fig. 3, most data points are below the diagonal. The lowering effect is greater the longer the normal-rate duration, and 35ms, the approximate boundary between the two sub-distributions in Fig. 2, is again informative:

around this point the trend line starts to move away considerably from the diagonal. In addition, a substantial minority of ICIs below 35ms disappear at fast rate –the stop sequences in question being realised with a short ICI at normal rate, and an unreleased first stop at fast rate. This is the case for only three ICI durations above 35ms. These findings are consistent with the existence of two sub-types of ICI, which respond differently to tempo variation.

Figure 3: ICI durations at normal and fast speech rates. Dotted diagonal marks equivalence; solid line the observed trend (quadratic fit). Dotted vertical line marks ICI duration of 35ms.



3.2. Relationship with epenthesis site

Given the sequences in (1) above, we can distinguish the epenthesis sites in (2). The sites which establish TLA as a 'VC' dialect [7] are ❹ and ❻ in this classification.

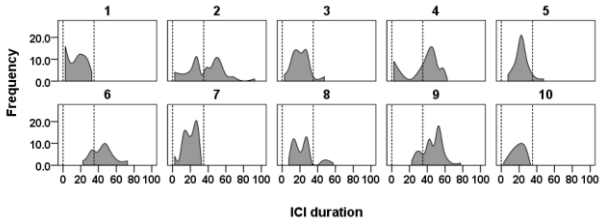
(2) a. ##C❶CV-
b. -VC❷C##
c. -VC❸#CV-
d. -VC❹#C❺CV-
e. -VC❻C❼#CV-
f. -VC❽C❾#C❿CV-

Fig. 4 shows that ICI durations are distributed in two ways depending on epenthesis site: at six epenthesis sites, the vast majority of ICIs are below 35ms, with peaks around 20ms; at four sites, the majority of ICIs are above 35ms, with typical peaks between 40 and 50ms and, in the cases of sites ❻ and ❾, a complete absence of zero ICIs. This is confirmed by an ANOVA with ICI duration as dependent variable, epenthesis site and voicing as fixed effects and speaker identity as random effect: the effect of site is highly significant ($F=37.171$, $df=9$, $p<0.001$). Post hoc analysis (Tukey's HSD) shows that the two ICI groups in (3) form homogeneous subsets.

(3) Short ICI {❶❸❺❼❽❿} Long ICI {❷❹❻❾}

Fig. 4 and (3) show that the two epenthesis sites which establish TLA as a 'VC' dialect, ❹ and ❻, are among those at which ICI durations above 35ms are the norm. In addition, long ICI durations are observed at ❷, between two stops in a final coda cluster, and ❾, at the word boundary in four-stop sequences. Note that the duration distributions durations are relatively wide at these sites. In particular, at ❷ a substantial minority of durations are below 35ms, to the extent that the distribution looks bimodal. By contrast, sites at which short ICI durations are the norm show very few durations that exceed 35ms. We will return to this observation.

Figure 4: Distribution of ICI durations (in ms) at normal speech rate, split by epenthesis site. The dotted vertical lines mark ICI durations of 0ms and 35ms.



3.3. Relationship with voicing

To investigate the relationship between ICI duration and voicing, we can first consider Fig. 5, which splits the histogram in Fig. 2 above by ICI voicing. This shows that voiced ICIs are distributed bimodally, with peaks around 20ms and 45ms, while the distribution of voiceless ICIs is unimodal (if not normal), centering around 25ms. An ANOVA with epenthesis site and voicing as fixed effects and speaker identity as random effect confirms that voiced ICIs are significantly longer than voiceless ones on average ($F=30.894$, $df=2$, $p<0.001$), although the distribution of voiced ICIs suggests two subtypes can be distinguished: short voiced ICIs, which are similar in duration to most voiceless ICIs, and long voiced ICIs, which are longer than most voiceless ones. Unsurprisingly, long voiced ICIs are closely associated with the four 'long ICI' epenthesis sites in (3), and these sites show a greater incidence of ICI voicing (>70%) than the six 'short ICI' sites (<50%, $\chi^2=11.850$, $df=2$, $p=0.003$).

As indicated above, [5]'s description of excrescent vowels suggests that these may vary in voicing depending on context, while epenthetic vowels are most commonly voiced. Fig. 6 visualises the relationship between stop and ICI voicing at the epenthesis sites in (2), focusing on sequences of two voiced and two voiceless stops. It shows that at the four 'long ICI' epenthesis sites in (3), ICIs are predominantly voiced, even when surrounded by

voiceless stops. By contrast, at the six 'short' sites all ICIs between voiceless stops are voiceless.

Figure 5: Distribution of ICI durations (in ms) at normal speech rate, for voiced ICIs (left) and voiceless ICIs (right).

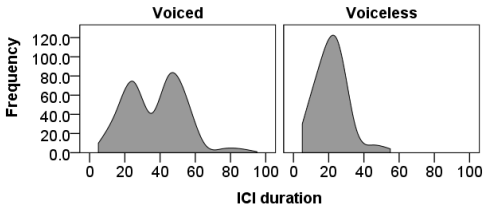
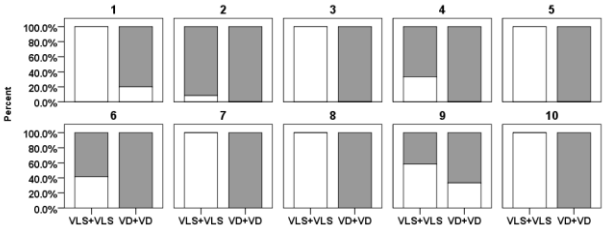
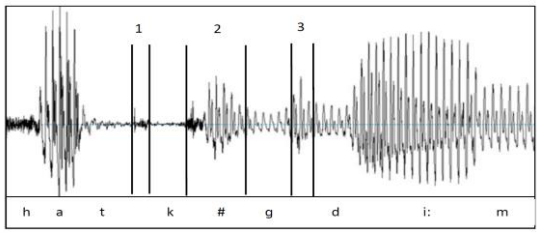


Figure 6: Proportions of voiced (grey) and voiceless (white) ICIs in voiced and voiceless stop sequences, split by epenthesis site.



Our data suggest that where stops do not match in underlying voicing, TLA displays similar voicing assimilation to Syrian Arabic [1]. Interestingly, assimilation appears to be constrained by ICI duration: it is frequently observed across short ICIs, but rarely across long ones. This is consistent with [5]'s observation that epenthetic vowels may block phonological processes, while excrescent vowels are typically transparent. Fig. 7 shows a -VCC#CCV- sequence with a short voiceless ICI (1) in /tk/, a short voiced ICI (3) in /gd/, and a long voiced ICI (2) at the word boundary, with no assimilation between /k/ and /g/. Further research is needed to establish the robustness of this pattern.

Figure 7: Waveform of /hatk#gdiːm/, with three ICIs delimited.



4. DISCUSSION

Our findings provide clear evidence for both excrescent and epenthetic vowels in TLA. At epenthesis sites -VC*v*C#CV- and -VC#C*v*CV-, which confirm TLA's status as a 'VC' dialect of Arabic [7], ICIs are rarely zero and mostly longer than 35ms. They are prone to shortening at increased speech rate, and are mostly voiced, even between voiceless stops. The same ICI type occurs at epenthesis sites -VC*v*C## and -VCC*v*#CCV-, while at all other sites, ICIs are rarely longer than 35ms, and ICI voicing is constrained by that of surrounding stops where those stops match in voicing.

The occurrence of an epenthetic vowel at epenthesis site -VCC*v*#CCV- is arguably not surprising, as the TLA syllable template does not permit clusters beyond CC: therefore, inserting an epenthetic vowel at the word boundary is the only way to break up a -CCCC- sequence without generating another illicit (CCC) cluster. The occurrence of an epenthetic vowel in utterance-final codas (-VC*v*C##) is perhaps more difficult to explain, but could be seen as an extension of the 'VC' epenthesis pattern in -VC*v*C#C- sequences, permitted by the relatively loose gestural coordination in coda clusters as compared with onset clusters [4]. Note that ICI durations are most variable at this site, suggesting that not all ICIs are unambiguously epenthetic vowels.

As for the excrescent vowels at other epenthesis sites, these can be seen as an aerodynamic consequence of a general tendency in TLA to avoid overlapping stop closures. The reason for this may be to allow for greater perceptual recoverability by listeners [3].

5. REFERENCES

[1] Barry, M., Teifour, R. 1999. Temporal patterns in Syrian Arabic voicing assimilation. *Proc. 14th ICPhS*, San Francisco, 2429-2432.

[2] Browman, C.P., Goldstein, L. 1992. Articulatory phonology: An overview. *Phonetica 49*, 155-180.

[3] Chitoran, I., Goldstein, L., Byrd, D. 2002. Gestural overlap and recoverability: Articulatory evidence from Georgian. In: Gussenhoven, C., Warner, N. (eds), *Papers in Laboratory Phonology 7*. Mouton, 419-448.

[4] Gafos, A. 2002. A grammar of gestural coordination. *Natural Language and Linguistic Theory 20*, 269-337.

[5] Hall, N. 2011. Vowel epenthesis. In: van Oostendorp, M., Ewen, C.J., Hume, E., Rice, K. (eds). *The Blackwell Companion to Phonology*. Malden, MA & Oxford: Wiley-Blackwell. 1576-1596.

[6] Kiparsky, P. 2003. Syllables and moras in Arabic. In: Féry, C., van der Vijver, R. (eds), *The Syllable in Optimality Theory*. Cambridge: Cambridge University Press. 147-182.

[7] Watson, J.C.E. 2007. Syllabification patterns in Arabic dialects: long segments and mora sharing. *Phonology 24*, 335-356.