Journal of Semitic Studies doi: 10.1093/jss/fgad028

EPENTHESIS AND VOWEL INTRUSION IN CENTRAL DHOFARI MEHRI*

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Abstract

The paper discusses epenthesis and vowel intrusion in the Central Dhofari variety of Mehri, one of six endangered Modern South Arabian languages indigenous to southern Arabia. Mehri is spoken by members of the Mahrah tribe in southern Oman, eastern Yemen, parts of southern and eastern Saudi Arabia and in communities in parts of the Gulf and East Africa. The estimated number of Mehri speakers is between 100,000–180,000. Following Hall (2006), this study distinguishes between two types of inserted vowels: epenthetic vowels, which repair illicit syllable structures, and intrusive vowels, which transition between consonants. The paper examines how the properties of epenthetic and intrusive vowels as proposed by Hall relate to Mehri.

* We thank the Leverhulme Trust for project grant RPG-2012-599 (January 2013–December 2016), during which time the orthography was developed for Modern South Arabian and some of the materials collected, and for a Major Research Fellowship (MRF-2018-121) awarded to the first author, during which time the majority of the materials were collected, and the data analyzed. Many thanks also to Barry Heselwood, Geoffrey Khan and Stuart Davis for commenting on earlier drafts, to participants at the 29th Manchester Phonology Meeting and the Semitic Dialectology Conference in 2022, to Andrea Boom and Carlos Jair Martínez Albarracín for collaborating on segmentation, to Saeed al-Qumairi for discussing epenthesis in the Mehri of Ḥawf, to Amer al-Kathiri for discussing vowel intrusion in Shehret, and, of course, to our Mehri consultants for patiently recording their data on various occasions.

0. Introduction

The paper discusses epenthesis and vowel intrusion in the Central Dhofari variety of Mehri, one of six endangered Modern South Arabian languages indigenous to southern Arabia. Mehri is spoken by members of the Mahrah tribe in southern Oman, eastern Yemen, parts of southern and eastern Saudi Arabia and in communities in parts of the Gulf and East Africa. The estimated number of Mehri speakers is between 100,000–180,000: precise figures cannot be obtained, however, as the language is spoken indigenously across three state borders and due to change in lifestyle many members of the Mahrah tribe no longer speak the language with any fluency. The paper will examine how the properties of epenthetic and intrusive vowels as proposed by Hall (2006) relate to Mehri.

Following Hall (2006), we distinguish between two types of inserted vowels: epenthetic vowels, which repair illicit syllable structures, and intrusive vowels, which transition between consonants. Hall chooses the term 'intrusive vowels' because of their similarity to intrusive stops (Clements 1987) in resulting from articulatory timing.[1] From an examination of data from 29 languages across different language families, Hall (2006, 391) lists characteristics of the distribution and quality of epenthetic and intrusive vowels. In this paper, we focus on characteristics of the distribution of the two vowel types rather than those of quality:

Properties of phonologically visible inserted vowels (epenthetic vowels)[2]

a. The vowel's presence is not dependent on speech rate.
b. The vowel repairs a structure that is marked, in the sense of being cross-linguistically rare.

Properties of phonologically invisible inserted vowels (intrusive vowels)

a. The vowel generally occurs in heterorganic clusters.

[1] Intrusive vowels have also been described as 'transitional vowels' (Rose 2000; Kreitman 2008, 2010), 'transitional vocoids' (Fougeron & Ridouane 2008; Ridouane & Cooper-Leavitt 2019), 'excrescent vowels' (Hall 2011; Heselwood et al. 2015) and 'intrusive vocoids' (Plug, Shitaw & Heselwood 2019). For other terms, see Levin (1987).

[2] The concept of phonologically visible and phonologically invisible inserted vowels is taken from Hall (2006) and supported by qualitative work with our speakers.

b. The vowel is likely to be optional, have a highly variable duration, or disappear at fast speech rates.
c. The vowel does not seem to have the function of repairing illicit structures. The consonant clusters in which the vowel occurs may be less marked, in terms of sonority sequencing, than clusters which surface without vowel insertion in the same language.

This paper consists of five sections. In section 1, we discuss our use of the terms 'breathed' and 'unbreathed' and present the consonant inventory of Mehri. In section 2, we present the methodology adopted for the paper. In sections 3–5, we show how Mehri epenthetic and intrusive vowels relate to the properties proposed by Hall. In section 3, we examine epenthesis in Central Dhofari Mehri. In section 4, we examine vowel intrusion. In section 5, we compare the duration of epenthetic and intrusive vowels with that of stressed and unstressed lexical vowels and consider the role of preceding and following consonant class on the duration of intrusive vowels.

1. Terminology

In this paper, we adopt the laryngeal category terms 'breathed' and 'unbreathed' following our previous work on laryngeal categories and glottal states in Mehri and Shehret (e.g. Heselwood & Watson 2021).[3] 'Breathed' denotes consonants traditionally described as 'voiceless',[4] while 'unbreathed' denotes segments that are canonically voiced and the emphatic obstruents that canonically lack both voicing and audible breath on release. The terminology emerges from the phonetics and from the phonological and morphological patterning of consonants in Mehri:

a) 'Breathed' consonants exhibit aspiration on release and degrees of pre-aspiration, which 'unbreathed' consonants lack; even when voiced in intersonorant position, 'breathed' fricatives maintain breathiness and, from our laryngographic work on Shehret, another MSAL, and impressionistic work on Mehri, exhibit an

[3] In Watson & Heselwood (2016), we adopt the features [open] and [closed] following Morén's (2003) parsimonious feature geometry model. In later work, we follow Heselwood & Maghrabi (2013, 2015) in the use of 'breathed' and 'unbreathed', terms which translate those used by the early Arab grammarian, Sībawayh, *mahmūs* and *majhūr*, and go back to Garbell (1958).

[4] 'Breathed' corresponds to Bendjaballah & Ségéral's 'idle glottis', first introduced by the authors in 2014.

abducted glottis typical of their canonical 'voiceless' form (Heselwood, Tomé Lourido & Watson 2022).

b) In utterance-final position, 'unbreathed' consonants exhibit pre-glottalisation and frequent post-glottalisation, which 'breathed' consonants lack.

c) Morpho-phonologically, 'unbreathed' emphatic and plain consonants pattern together in taking initial vowels (/a/ or /ə/) when heading a defined nominal and heading certain derived verb forms, as in: *ḳawt* 'food' > *əḳawt* 'the food', *bayt* 'house' > *abayt* 'the house', while 'breathed' consonants are typically, but not always as we see below, geminated in this position, as in: *śaysəb* 'leather satchel' > *śśaysəb* 'the leather satchel', *kənsīd* 'shoulder' > *(ə)kkənsīd* 'the shoulder' (Watson & Heselwood 2016, 8–13).

In the consonant table below, the 'breathed' consonants are presented in italics on the left side of the cells:

Table 1: Mehri consonantal phoneme table

	labial	**dental**	**alveolar**	**post-alveolar**	**palatal**	**velar**	**uvular**	**pharyn-geal**	**glottal**
plosive	b		*t* d ṭ			*k* g ḳ			
fricative	f	*ṯ* ḏ ṯ̣	*s* z ṣ	*š* ž ṣ̌			*x* ġ	*ḥ* ʕ	*h* ʔ
lateral fricative			*ś* ṣ́						
lateral sonorant			l						
nasal	m		n						
rhotic			r						
glide	w				y				

2. Methodology

2.1. Participants

The data for this paper come from fieldwork conducted between 2011 and 2022 with 14 speakers: 2 females (M073, M002) and 13 males, aged between 22 and 55. The speakers include 3 Mehri–Shehret speakers (J001, J003, M026), who have been bilingual in Mehri and Shehret from birth, learning Arabic at school. The remaining 11 speakers were brought up speaking Mehri at home and learning Arabic at school. The speakers are members of three Dhofar-based tribes: Bit Thuwār (9 speakers), Bit Samōdah (3 speakers), Bit al-Afāri (2 speakers). The two Bit al-Afāri speakers (M028, M073) are from the Oman–Yemen border in Ḥabrūt; the remaining speakers are from Central Dhofar; of these, 6 are from the central mountains: 3 from Āṭōd (M079, M080, M081) and 3 from Gabgabt (J001, J003, M026); and 7 are from the desert village of Rabkūt (M001, M002, M003, M019, M056, M057, M068).

2.2. Materials

The materials are words and short phrases elicited through written wordlists. Wordlists were presented to speakers in the Arabic-based orthography developed in January 2013 for Modern South Arabian during the Leverhulme Trust-funded *Documentation and Ethnolinguistic Analysis of Modern South Arabian* (DEAMSA) project.

Data for epenthesis were elicited by asking 6 male speakers from the tribes of Bit Samōdah (J001) and Bit Thuwār (Bit Ḳhōr subtribe) (M001, M003, M057, M068, M079), Central Dhofar, between the ages of 22 and 37 to produce the bare noun or verb stem followed by the stem with a consonant-initial possessive, subject or object suffix (*-kəm* 'your/you m.pl.', *-kən* 'your/you f.pl.', *-həm* 'their/them m.' or *-sən* 'their/them f.'), repeating the bare stem and each target word three times. Items in the word lists were selected in consultation with the third author. The wordlist for epenthesis included the following stems to which possessive, subject or object pronouns were added as appropriate:

Table 2: Wordlists for epenthesis

Noun	Gloss	Perfect verb	Gloss
ʔagz	Laziness	mīrət	To become hot
ṯarb	Stick	rīkəb	To ride
farḳ	Large goat herd	lībəs	To wear
raḳb	Small cave; ledge	wīṣəl	To arrive
xarg	Saddle bag	fīrəḥ	To be glad
baḳṣ́	Running	ṯībər	To break intr.
ṭafḥ	Steep slope	fīṭən	To remember
ṣanf	Type	kīṯər	To be many
śaysəb	Leather satchel	śītəm	To buy
śēḥəz	Frankincense	bīṣ́ər	To tear
ḥōṭər	Female goat kid	mīrəṣ́	To be unwell
ḥōrəm	Road; way	śīrəġ	To desire
		nīḳəb	To fall

Imperfect verb	Gloss	Perfect verb	Gloss
yəġōrəb	He knows	ḳayrəb	To be close
yəṭawməl	He closes [his eyes]	xayṯəm	To be thin
yəkūtəb	He writes	ḥayrəḳ	To be hot
yəśūnəḳ	He hangs	ḥayṯ̣əf	To be impoverished
yəbūdər	He races	ayməl	To do
yəhūrəḳ	He steals	aygəb	To like
yəxawdəm	He works	ṣawləḥ	To be fat
yəwūkəb	He enters	nūṣ́əḥ	To advise
yəwūzəm	He gives	arōtəb	To arrange
yəśūrəg	He stitches	arōḳəd	To dance
yəḥawləg	He rolls out	əhhōnəd	To be sleepy
yəsūbəṭ	He hits	əssōfər	To travel
yəlūbəd	He hits	šnēsəm	To sigh
yəśūbəḳ	He tethers camels in line	amaḳṣəd	To take a short cut
yənūsəb	He recounts past favours	aḳarfəd	To turn over
yəsūbək	He fixes	ratbəḳ	To run alongside e.o.
yəśūbək	He nets	ḥatrək	To move
yəʕawṣəb	He ties, binds	ṣatmər	To suffer from noise

Data for intrusive vowels were extracted from these word lists, from other word lists drawn up by the first and third authors and collected by the first author for the remaining speakers mentioned above, and, for impressionistic analysis, from narratives collected by the first author.

2.3. Procedure

For the epenthesis section of this paper, we analyzed wordlist data sets recorded on:

a) Olympus LS-11 digital recorder with inbuilt microphone and saved in WAV format 44KHz, 16bit;
b) Laryngograph EGG-D200 microprocessor with an ECM 500L/SK lapel microphone;[5]
c) iPhones using the Voice Memos app and converted to WAV format, during the Covid-19 pandemic.

[5] The laryngographic data are being analyzed separately in a study of consonantal phonemes. The acoustic analysis of data collected on the laryngograph was conducted through extraction of the acoustic channel (channel 1) from the laryngographic file on Praat (Boersma & Weenink 2021).

Although the use of different devices may have an effect on spectral measures, such as vowel formants, a recent paper shows that vowel duration measurements were similar across external microphone and smartphone devices (Sanker et al. 2021, e370) and both of these devices were able to capture duration differences caused by stress (e373). All data were transcribed and segmented in Praat TextGrids with ten tiers: transcription, words, segments, translation, interesting points, stress, prosodic, formants, VOT, release. The relevant tiers for this work are tier 2 'words', tier 3 'segments', tier 5 'interesting points' and tier 7 'prosodic'. Intrusive and epenthetic vowels were marked on tier 5 'interesting points' as IV (intrusive vowel) or EV (epenthetic vowel). Primary and secondary stressed feet were marked as sf 'stressed foot' and uf 'unstressed foot' on tier 7 'prosodic'.[6] Transcription and segmentation were conducted by the first author in collaboration with two doctoral students. All TextGrids were reviewed and edited by the first author for internal consistency. The second author wrote the Praat scripts, analyzed the data and conducted the statistical analysis.

3. Epenthesis in Mehri

In our discussion of epenthesis in Mehri, we begin by examining syllable structure. We then consider syncope and epenthesis in the case of morphological concatenation.

3.1 Syllable structure in Mehri

The basic syllables in Mehri are given in (1):

(1) (C)CV, (C)CVC, (C)CVV, CVVC and CVCC. Of these, (C)CV and stem-final CVC syllables are light for stress purposes, and the remaining syllables are heavy. CVVC and CVCC are, with few exceptions, restricted to word-final position, and syllables with onset clusters are restricted to word-initial position. As

[6] Feet in Mehri are bimoraic trochees. Primary word stress is assigned to a final superheavy syllable, otherwise to the right-most heavy (CVV or CVC) syllable of the word stem, or to a word-final dual suffix or final weak verb ending, with secondary stress assigned to heavy syllables to the left of the primary stressed syllable. Thus, the right-most syllable in *bī.rōk* 'knees' takes primary stress and the initial syllable takes secondary stress. In the absence of a heavy syllable or stressable suffix in the word, stress is assigned to the left-most CV syllable of the word stem, as in *yəgáwər* 'he falls', *láhina* 'but'. For details of Mehri word stress, see Lonnet & Simeone-Senelle (1983), Watson & al-Mahri (2018) and Watson et al. (2020, 57–9).

discussed in Bendjaballah & Ségéral (2014), longer consonant clusters can arise in Mehri in case of the concatenation of sequences of 'breathed' (in their terminology 'idle glottis', in the terminology of Johnstone and other researchers 'voiceless') consonants. Longer consonant clusters can also arise in the concatenation of plosives, as we see below. These syllable types are recognized for Mehri by Lonnet & Simeone-Senelle (1983, 354), Rubin (2010, 2018), Watson (2012) and Watson et al. (2020). Working within Government Phonology, Bendjaballah & Ségéral (2017) recognize only (C)CV, CVC and CVCC for Mehri.

3.2 Syllabification, syncope and epenthesis

In terms of syllabification, Central Dhofari Mehri corresponds to what Kiparsky (2002) describes as a VC-dialect (here VC-language or VC-variety) in his analysis of syllabification across Arabic dialects. That is to say, where the concatenation of morphemes produce a sequence of three medial consonants ($C_1C_2C_3$), epenthesis in the unmarked case occurs to the left of the unsyllabified consonant (C_2) (Watson et al. 2020, 106–7) as opposed to the right of the unsyllabified consonant for CV-dialects. This finding contrasts with the majority of transcriptions provided by Johnstone (1987) in *Mehri Lexicon* and elsewhere.[7] Examples of epenthesis from our data in the

[7] Examples include: *arákbəki*, *arákbəkəm* and *arákbəkən* (1987, xxxiv; also Rubin 2010, 94), *šənásməkəm* and *šənásməkən* (1987, lxiii; also Rubin 2010, 108). Johnstone does, however, transcribe the epenthetic vowel between C_1 and C_2 in the following examples: *t̠əbərtō*, *t̠ábərkəm* and *t̠ábərkən* (1987, xxii; also Rubin 2010, 91–2), *wəṣəltō*, *wə́ṣəlki*, *wə́ṣəlkəm* and *wə́ṣəlkən* (1987, xxix), *kəwərtō*, *kə́wərki*, *kə́wərkəm* and *kə́wərkən* (1987, xxx), and *dátərməm* 'they killed e.o.' (1987, 74), probably due to awareness of the C_2 sonorant (cf. however, *šənásməkəm* and *šənásməkən* above). If these transcriptions accurately reflected the situation in Central Dhofari Mehri, it would appear that Mehri partly obeys syllable contact laws in the positioning of the epenthetic vowel, as found for the Ethiopian Semitic language, Chaha (Rose 2000). Most of Johnstone's data come from Ali Musallam, a consultant with whom the first author of this paper also worked until a year before his death in 2013. Although we lack data from Ali Musallam for forms such as *arōkəb-kəm* and *yəkūtəb-kəm*, speakers we have consulted from Ali Musallam's tribe of Bit Thuwār (sub-tribe Bit Āmawsh) of around his age typically insert epenthetic vowels in $C_1C_2C_3$ clusters between C_1 and C_2 irrespective of the sonority profile of the cluster, excepting cases where C_1C_2 form an indivisible unit (3.2.1–3.2.5). This observation suggests either language change since the 1970s when Johnstone produced his work, as suggested by Stuart Davis (p.c.), or transcription error on the part of Johnstone. There is some evidence from Rubin's work on Johnstone's texts (2018) that Johnstone did make occasional transcription errors in the narrative texts; however, as we are unable to locate texts that show epenthetic vowels, we are

case of CVCC words plus CVC suffixes include the examples in (2) (from here on, epenthetic vowel highlighted in **bold**). Note here that the initial vowel represents the definite article, as shown in Section 1 c):

(2) *ṯ̣árb-kəm* > *aṯ̣ár***ə***bkəm* ‘your m.pl. stick’
ʔ̇ágz-həm > *(a)ʔ̇ág***ə***zhəm* ‘their m. laziness’
báḳṣ́-kəm > *abáḳ***ə***ṣ́kəm* ‘your m.pl. running’
ráḳb-kəm > *aráḳ***ə***bkəm* ‘your m.pl. cave’
ṣánf-kəm > *aṣán***ə***fkəm* ‘your m.pl. type’

As for the majority of Arabic VC-dialects (Kiparsky 2002), word stress fails to migrate to the epenthetic vowel even when that vowel apparently falls in the right-most heavy syllable, resulting in stress opacity (Kiparsky 2000, 2002; Watson 2011; Hall 2013).[8] Examples of opaque stress in Arabic VC-dialects include *fíh***i***mna* ‘our understanding’ (Hall 2011, 1586), *šíf***i***tha* ‘I saw her’, *katáb***i***t* ‘I wrote’ (Kiparsky 2000) and *líb***i***sna* ‘our clothes’ (Hall 2013, 133), with epenthetic vowels highlighted in **bold**.

In contrast to documented VC-Arabic dialects, phonotactic factors conspire to affect the presence or position of the epenthetic vowel in Central Dhofari Mehri. Before considering the syllabification processes that lead to stress opacity, we examine these phonotactic factors. In addition to geminate integrity, which also plays a role in Arabic VC-dialects, C_1C_2 may form an indivisible unit in five cases, either prompting epenthesis to the right of C_2 or resulting in lack of epenthesis, namely: clusters of ‘breathed’ consonants (cf. Bendjaballah & Ségéral 2014); homorganic nasal + obstruent sequences; /r/ followed by a coronal; /r/ followed by an ‘unbreathed’ velar or uvular; and /b/ followed by an obstruent (front–back obstruent clusters). Of these, geminates result either in epenthesis to the right of C_2 or no epenthesis. /r/ followed by a coronal, /r/ followed by an ‘unbreathed’ velar or uvular, homorganic nasal + obstruent sequences typically, but not invariably, result in epenthesis to the right of C_2 or no epenthesis; /b/ followed by an obstruent (front–back obstruent clusters) often results in lack of epenthesis. We look at each of these in turn.

unable to state with any degree of certainty whether this constitutes transcription error or recent language change.

[8] Lonnet & Simeone-Senelle (1983, 354) correctly describe epenthetic vowels in Mehri as failing to take stress.

3.2.1 Geminate integrity

The principle of geminate integrity (e.g. Kenstowicz & Pyle 1973; Davis 2011) ensures that geminate consonants form an indivisible unit: in Mehri, where C_1C_2 are occupied by an 'unbreathed' geminate and C_3 is 'breathed' or where C_1C_2 are occupied by an 'breathed' geminate and C_3 is 'unbreathed', an epenthetic vowel is typically realized to the right of the geminate, as in: *ṣəbb-kəm* > *ṣə́bbəkəm* 'you m.pl. poured', *ḥəgg-kəm* > *ḥə́ggəkəm* 'you m.pl. went on the pilgrimage', *śəḳḳ-kəm* > *śə́ḳḳəkəm* 'you m.pl. split', *yəṣṣ-kən* > *yə́ṣṣəkən* 'you f.pl. are afraid' and *śabb-kəm* > *śśábbəkəm* 'your m.pl. young man', as illustrated in Figure 1.

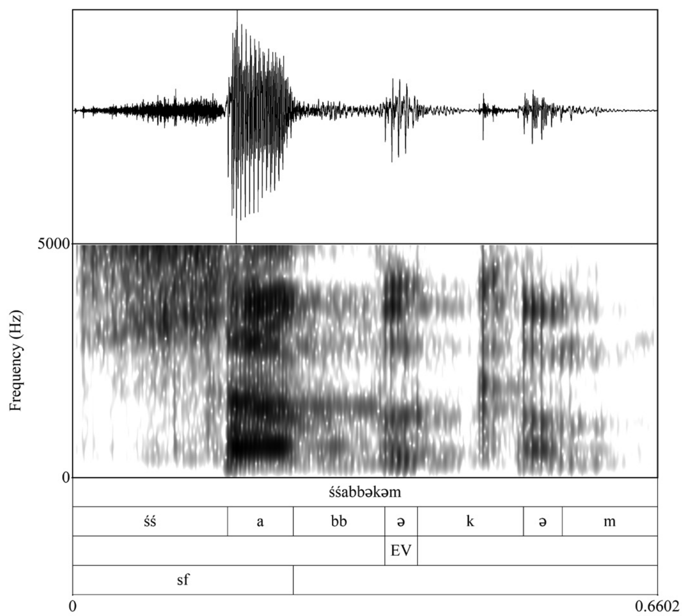

Figure 1: M057: *śśábbəkəm* 'your m.pl. young man'

Sequences of an 'unbreathed' geminate followed by a 'breathed' consonant, however, may lack epenthesis where the final syllable takes primary word stress. Thus, the following variants are attested in the data: *rəddtóh~rəddətóh* 'they f. dual returned', *ḥəggtóh~ḥəggətóh* 'they f. dual went on the pilgrimage', *nəṣṣtóh~nəṣṣətóh* 'they f. dual cleaned meat off bone'. The duration of the geminate in non-epenthesised forms at ~200ms is similar to geminates in intervocalic position in, for example, *rəddóh* 'they m. dual returned', *ḥəggóh* 'they m. dual went on the pilgrimage', *nəṣṣóh* 'they m. dual cleaned meat off bone'. This is illustrated in Figures 2a–b where *nəṣṣtóh* has a pre-consonantal geminate duration of 201ms compared to *nəṣṣóh* with an intervocalic geminate duration of 196ms.

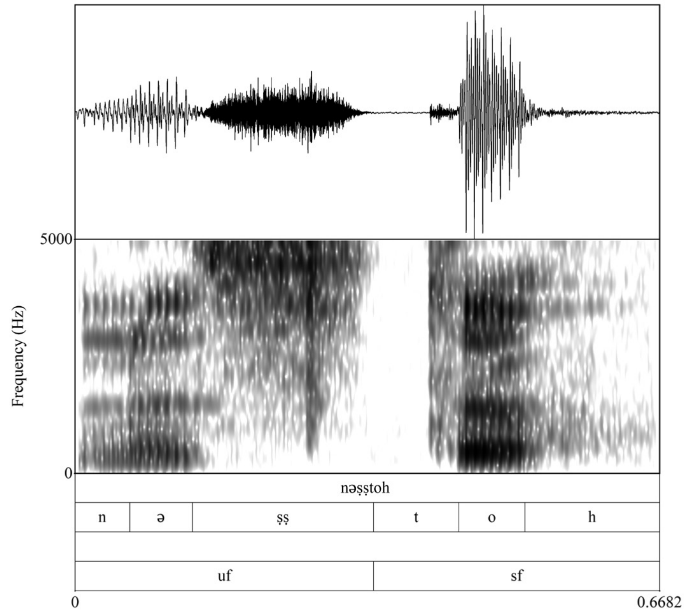

Figure 2a: M001: *nəṣṣtóh* 'they f. dual took meat off bone'

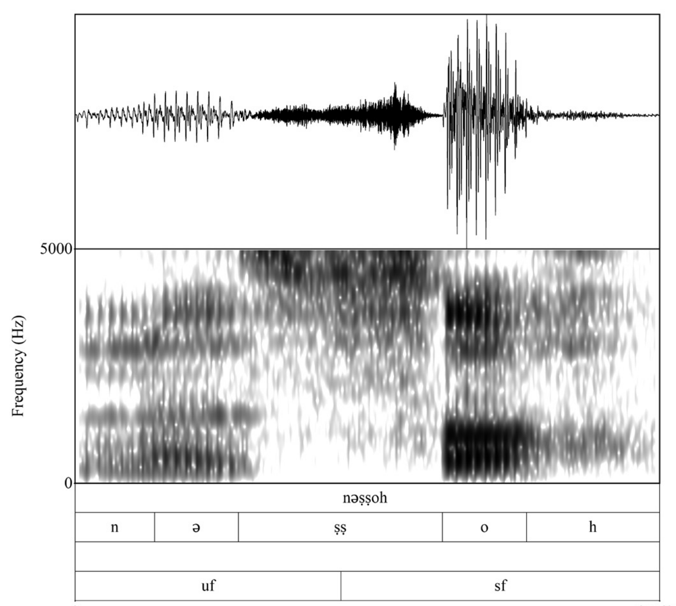

Figure 2b: M001: *nəṣṣóh* 'they m. dual took meat off bone'

3.2.2 Homorganic nasal + obstruent

Where C_1 is the coronal nasal, /n/, an epenthetic vowel is typically either inserted to the right of C_2 or fails to be realized,[9] as in: *əhhōnəd-kəm* > *əhhandəkəm*~*əhhandkəm* 'you m.pl. became sleepy', *yəśūnəḳ-həm* > *yəśənḳəhəm*~*yəśənḳhəm* 'he hangs them m.'. The coronal nasal is unmarked cross-linguistically, and in Mehri and many other languages usually assimilates in place to a following obstruent (see Watson 2002 for Arabic); thus, /n/C is analysed as a homorganic nasal + obstruent cluster, sequences which frequently resist division cross-linguistically (cf. Ohala 2003; Kaplan 2006 for Misantla Totonac). Where C_2 is 'breathed', however, any epenthesis occurs to the left of C_2, as in: *ṣanf-kəm* > *aṣánəfkəm*~*aṣánfkəm* 'your m.pl. type'. Epenthesis between /n/ and a following 'breathed' cluster is due to the high-ranking constraint against splitting 'breathed' clusters with an unstressed vowel, as we see in 3.2.3 below.

3.2.3 'Breathed' clusters

'Breathed' clusters are typically not split by an unstressed vowel. Where C_1 and C_2 are both 'breathed' and C_3 is 'unbreathed', C_1C_2 form an indivisible unit, with the result that epenthesis occurs to the right of C_2, as in: *əsfrēt* > *əsfərēt* 'she travelled'. Where $C_1C_2C_3$ are all 'breathed', no epenthesis occurs among any of our speakers, as in: *fəṭḥ-kəm* > *fəṭḥkəm* 'you m.pl. opened', *nəfx-kən* > *nəfxkən* 'you f.pl. blew', *ṭafḥ-kəm* > *aṭafḥkəm* 'your m.pl. steep slope'. An example of a cluster of three 'breathed' consonants is provided in Figure 3.

The generally causative H-stem verbs when they lack the *hə-* prefix before a root-initial 'breathed' consonant typically geminate the root-initial consonant, prompting epenthesis, as in *(ə)ffərūḳ* 'to frighten' (given in Johnstone 1987 as *frōḳ*, but in Dufour 2016, 181 as *(f)frūḳ*), *(ə)ṯṯəbūt* (given in Johnstone 1987 and Dufour 2020 as *ṯbūt*).[10]

[9] As mentioned by an anonymous reviewer, homorganic nasal + obstruent sequences are often referred to in the phonology literature as 'partial geminates' and may pattern similarly to geminates in resisting epenthesis, as we see at least partially here.

[10] H-stem verbs invariably take the *hə-* prefix where the initial stem consonant in 'unbreathed', as in: *ḥəbkoh* 'to cause to cry', *həḳdūm* 'to bring forward', or where the first two stem consonants are 'breathed', as in: *həśkūr* 'to get lots of milk when milking'. In the Russian–Soqotri team's work, ultra-short vowels in the causative stem are transcribed as superscript vowels, as in: *ḥérog* 'to flow, to leak' > *ḥ^{a}reg* 'to make go down', *sákaʿ* 'to cross a wadi' > *s^{e}kaʿ* 'to transfer someone across a wadi', *férod* 'to flee' > *f^{e}red* 'to make flee, to expel' (e.g. Kogan & Bulakh 2019; Bulakh 2021). Dufour (2016, 180) describes Shehret H1-stem verbs with an initial

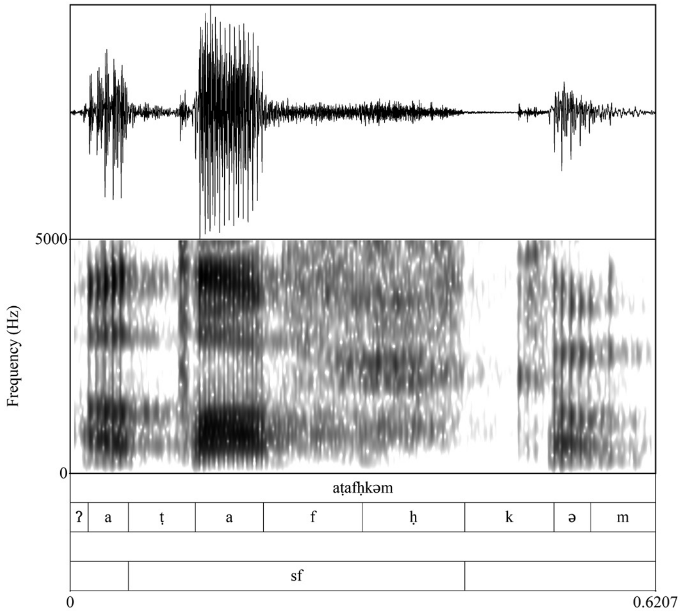

Figure 3: M057: *aṭafḥkəm* 'your m.pl. steep slope'

Where /h/ is pronounced exceptionally in H-stem verbs with an initial 'breathed' and following 'unbreathed' root consonant, the vowel of the prefix is elided by some speakers[11] due to the 'breathed'–'breathed' contact (cf. Bendjaballah & Ségéral 2014), prompting epenthesis between C_1 and C_2 of the root, as illustrated in Figure 4.

As seen above in Figure 3, where all members of the $C_1C_2C_3$ cluster are 'breathed', no epenthetic vowel is realized (as first predicted by Bendjaballah & Ségéral 2014); however, as seen in Figures 5 and 6 where C_1 or C_2 is a plosive, the typical plosive release may give the auditory impression of an epenthetic vowel: in *yəfask-kəm* > *yəfáskkəm* 'he separates you m.pl.', for example, concatenation does not result typically in a concatenated geminate [kk], but rather in two separately released tokens of /k/.

In the case of a 'breathed' geminate occupying C_1C_2 or C_2C_3 in a breathed word-internal $C_1C_2C_3$ cluster, the geminate maintains its

'breathed' C (his 'idle glottis' = ©) and a following 'unbreathed' C as taking an intrusive vowel between C_1 and C_2, as in: *ḥaréf* 'to close, *kəbér* 'to visit', *təlék* 'to lead'.

[11] Compare the same word by J001 in Figure 27 in which a vowel is realized between /h/ and the initial 'breathed' root consonant.

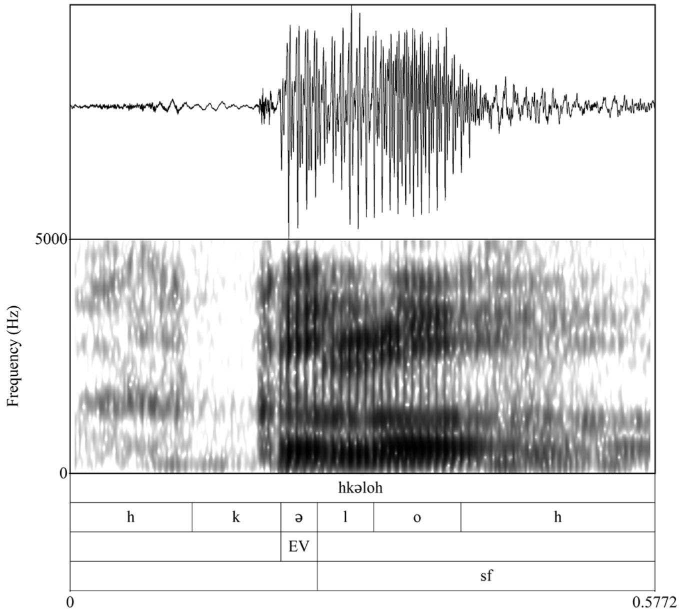

Figure 4: M001: *hkəlóh* 'to bring livestock back to the homestead in the evening'

duration, as we saw for 'unbreathed' geminate followed by stressed C-initial syllable in Figure 2a. Examples include: *ḥəss-kəm* > *ḥəsskəm* 'you m.pl. felt', *ʕəśś-kəm* > *ʕəśśkəm* 'you m.pl. got up' (contrast *ḥəsk tah* 'I/ you m.s. felt him' < *ḥəssək tah, where /s/ has the duration of a singleton). Where the 'breathed' geminate is a plosive, the geminate plosive is almost always released in our data, even where it is homorganic with C_3, as in *ṣəkk-kəm* > *ṣəkkkəm* 'you m.pl. shut'. The same applies when a 'breathed' plosive is followed by a 'breathed' geminate plosive across words, as in: *bxaṣk kkənsaydi* 'my shoulder hurts'. Thus, C_1C_2 or C_1 exhibit clear inter-consonantal intervals (ICIs) (e.g. Plug, Shitaw & Heselwood 2019; Alsubaie, in prep.) in the form of aspiration, which may give the auditory impression of an epenthetic vowel. We show burst (B) and aspiration noise (N) of the first /k/ on tier 3 of the TextGrids in Figures 5 and 6, transcribing the voiceless ICIs with a superscript ^{h}.

3.2.3 Retroflex clusters/singletons

/r/ followed by a coronal produces a retroflex cluster or singleton (cf. Simeone-Senelle 1997 for Mehri spoken in Yemen), often, in the case of CVCC words, with a lengthened initial vowel, as in *ḳarš* [ḳɑːʂ] 'money; riyal'. Where C_1 is /r/ and C_2 a coronal in a $C_1C_2C_3$ cluster,

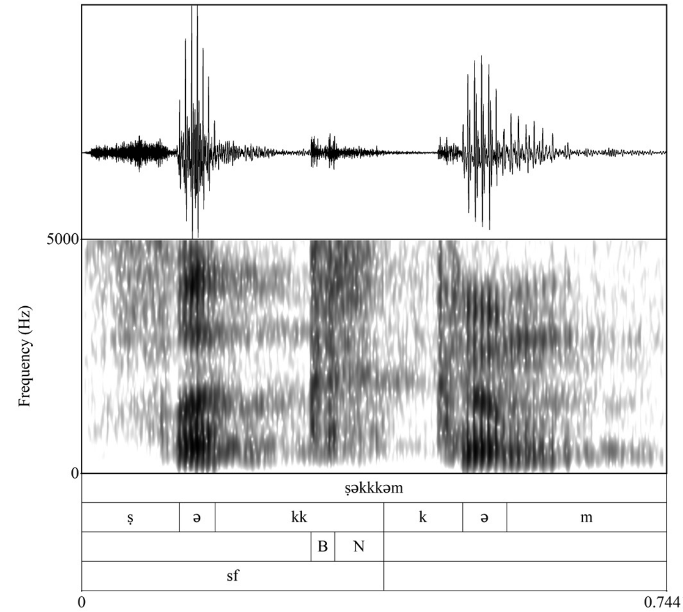

Figure 5: M001: *ṣəkk^hkəm* 'you m.pl. shut'

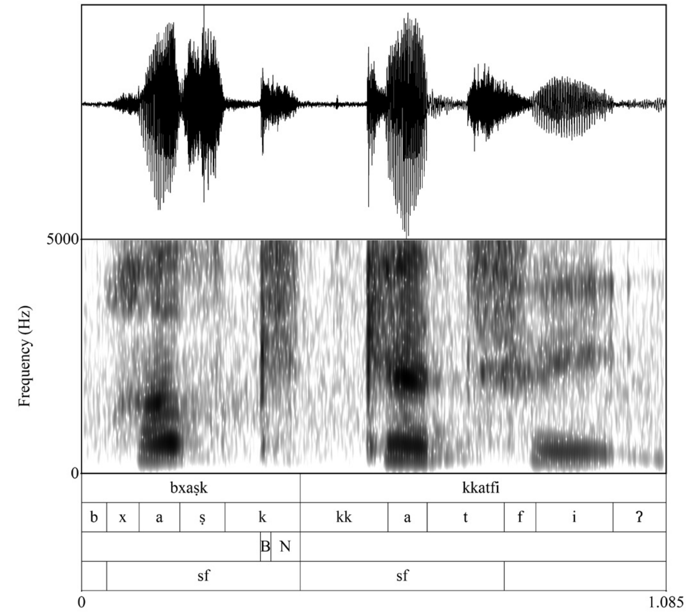

Figure 6: M073: *bxaṣk^h kkatfi* 'my shoulder hurts'

the ensuing retroflex cluster or singleton is indivisible, with the result that no epenthetic vowel is inserted, as in: *mīrət-kəm* > *mə́ʈkəm* ‘you m.pl. became red hot’, *mīrəṣ́-kəm* > *mə́rṣ́kəm* ‘you m.pl. became ill’. In very careful speech, a few tokens are attested where /r/ plus coronal does not result in a retroflex and an intrusive vowel occurs to the left of C_2, as illustrated in Figure 7.

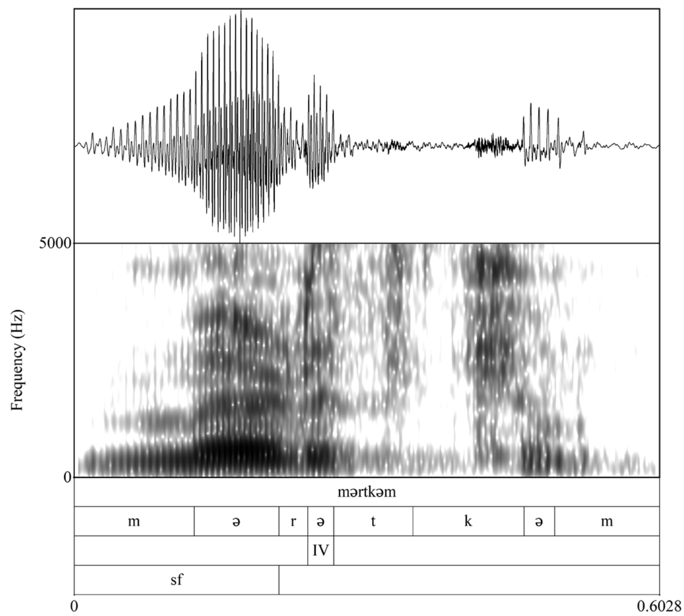

Figure 7: J001: *mə́rtkəm* ‘you m.pl. became red hot’

3.2.4 /r/ + velar/uvular

A velar or uvular obstruent preceded by /r/ as C_1C_2 may form an indivisible unit, typically exhibiting an intrusive vowel between C_1 and C_2. Epenthesis usually follows an ‘unbreathed’[12] velar or uvular C_2, as illustrated in Figure 8.

Further examples include: *xarg-sən* > *xxárgəsən* ‘their f. saddle bag’, *farḳ-kəm* > *(ə)ffárḳəkəm* ‘your m.pl. large flock of goats’, *ḥayrəḳ-kəm* > *ḥə́rḳəkəm* ‘you m.pl. became hot’. By contrast, where the C_2 velar or uvular is preceded by a sonorant other than /r/ (or /n/) epenthesis

[12] Where the velar or uvular is ‘breathed’, we would predict no epenthetic vowel to be realized between C_2 and C_3 (Bendjaballah & Ségéral 2014). However, no examples of /rk/ followed by a ‘breathed’ consonant appear in our database.

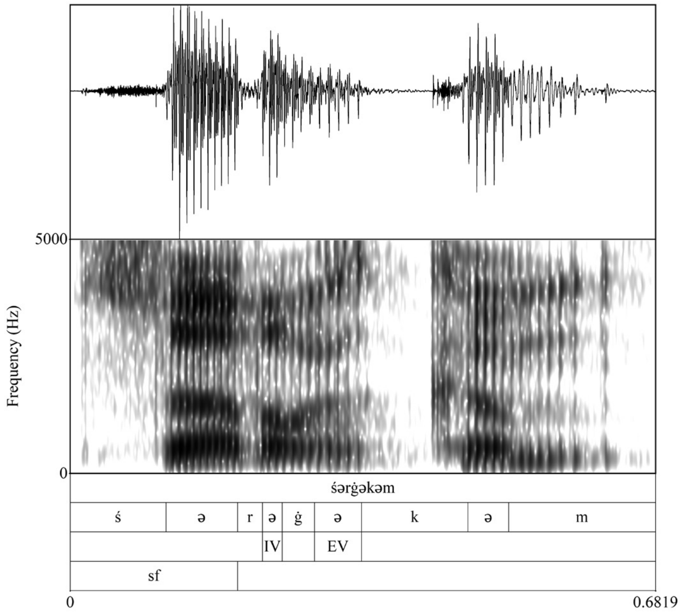

Figure 8: M001: *śə́rġəkəm* 'you m.pl. desired'

typically occurs to the left of C_2, as predicted, as in: *yəḥawləg-sən* > *yəḥəlg-sən* > *yəḥə́ləgsən* 'he rolls them f.'.

3.2.5 Front–back place order

Place order of consonants in the oral cavity and manner of articulation can affect whether or not an epenthetic vowel is realized. Where C_1 is a labial plosive, /b/, followed by an obstruent, several speakers produce no epenthesis. In the discussion of intrusive vowels in section 4.3.2 below, we will see that the front–back place order conspires with manner of articulation to result in lack of vowel intrusion or a shorter intrusive vowel when compared with back–front sequences. The realization or lack of realization of epenthesis is, however, speaker dependent: examples of lack of epenthesis in /b/+obstruent sequences include the following from M001, M002 and M068: *yəsūbəṭ-kəm* > *yəsə́bṭkəm* 'he hits you m.pl.', *yəlūbəd-sən* > *yələ́bdsən* 'he hits them f.', *yəśūbəḳ-sən* > *yəśə́bḳsən* 'he tethers them f. in a line' and *yəsūbək-sən* > *yəsə́bksən* 'he fixes them f. together'. These compare with tokens from M019 and M057 in which an epenthetic vowel is typically present in /b/+obstruent clusters, as in: *nabṭ-kəm* > *anábəṭkəm* 'your m.pl. camel birth', *yəsūbək-sən* > *yəsə́bəksən* 'he fixes them f. together' and *yəśūbəḳ-sən* > *yəśə́bəḳsən* 'he tethers them f. in a line'. Where no epenthesis is realized in the case of plosive clusters, the fact that plosives are typically released, as seen above in section 3.2.2, resulting in audible ICIs between the release of one plosive and the closure of the next can confound the listener into perceiving a vowel unless close acoustic analysis is conducted. A typical example of lack of epenthesis with clear plosive releases of /b/ and /ṭ/ is given in Figure 9.

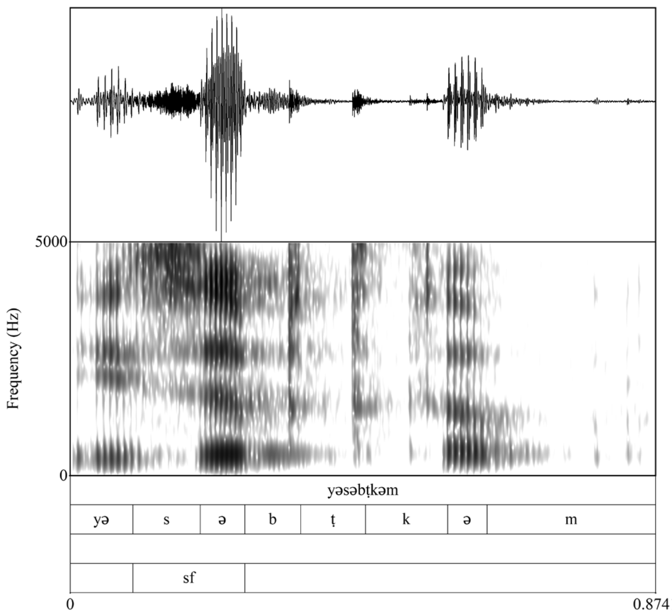

Figure 9: M068: *yəsə́bṭkəm* 'he hits you m.pl.'

3.3 Syncope, Closed Syllable Shortening and epenthesis

In contrast to documented modern Arabic dialects, Mehri syncope deletes an unstressed vowel in the stem-final syllable on morphological concatenation, irrespective of whether the target syllable is open (CV), as in the examples in (3), or closed (CVC), as in the examples in (4):

(3) Pre-suffix syncope
śaysəb-i > *(ə)śśaysb-i*
ḥōṭər-i > *ḥḥōṭr-i*
ḥatrək-əm > *ḥatrk-əm*
ratbəḳ-əm > *ratbḳ-əm*

(4) Pre-suffix syncope
śaysəb-kəm > *(əś)śaysb-kəm*

ḥōṭər-kəm > *ḥḥōṭr-kəm*
śēḥəz-sən > *(əś)śēḥz-sən*
rīkəb-kəm > *rīkb-kəm*
nīḳəb-kəm > *nīḳb-kəm*
nīśəz-kəm > *nīśz-kəm*
arōtəb-kəm > *arōtb-kəm*
yəḥawləg-sən > *yəḥawlg-sən*
yəkūtəb-həm > *yəkūtb-həm*
yəʕawṣəb-kəm > *yəʕawṣb-kəm*
amaḳṣəd-kəm > *amaḳṣd-kəm*
ḥatrək-ki > *ḥatrḳ-ki*

Reduction of CəC to CC motivates Closed Syllable Shortening (CSS) where the stressed vowel of the stem is long (/ay/, /ī/, /ū/ > [ə]; /ē/, /ō/ > [a], Johnstone 1987, xiv), as in (5):

(5) Closed Syllable Shortening
śaysb-i > *(əś)śəsb-i*
ḥōṭr-i > *ḥḥaṭr-i*
śaysb-kəm > *(əś)śəsb-kəm*
ḥōṭr-kəm > *ḥḥaṭr-kəm*
śēḥz-sən > *(əś)śaḥz-sən*
rīkb-kəm > *rəkb-kəm*
nīśz-kəm > *nəśz-kəm*
arōtb-kəm > *aratb-kəm*
yəḥawlg-sən > *yəḥəlg-sən*
yəkūtb-həm > *yəkətb-həm*
yəʕawṣb-kəm > *yəʕəṣb-kəm*

Once concatenation and syncope has created a $C_1C_2C_3$ cluster, all things being equal, epenthesis in a language that disfavours $C_1C_2C_3$ clusters may occur either to the left or the right of the unsyllabified consonant (C_2). In CVCC-CVC, CVVCVC-CVC and CVCCVC-(C)V(C) strings, the epenthetic vowel is, apart from the exceptions discussed in 3.2, inserted to the left of C_2, as in (6–8). Stress remains on the original stressed syllable of the stem:

(6) Epenthesis: CVCC-CVC strings
baḳś-kəm > *abáḳəśkəm* 'your m.pl. running'
ʔagz-kəm > *aʔágəzkəm* 'your m.pl. laziness'
ṯarb-kəm > *aṯárəbkəm* 'your m.pl. stick'

(7) Epenthesis: CVVCVC-CVC strings
śaḥz-kəm >*(əś)śáḥəzkəm* 'your m.pl. frankincense'
śəsb-kəm > *(əś)śə́səbkəm* 'your m.pl. leather satchel'
ḥaṭr-kəm > *ḥḥáṭərkəm* 'your m.pl. female kid'

rəkb-kəm > *rə́kəbkəm* 'you m.pl. rode'
nəḳb-kəm > *nə́ḳəbkəm* 'you m.pl. fell off'
nəśz-kəm > *nə́śəzkəm* 'you m.pl. drank tea'
aratb-kəm > *arátəbkəm* 'you m.pl. arranged'
yəḥəlg-sən > *yəḥə́ləgsən* 'he rolls them f.'
yəʕəṣb-kəm > *yəʕə́ṣəbkəm* 'he binds you m.pl.'

(8) Epenthesis: CVCCVC-VC strings
haḳfəd-i > *háḳəfdi* 'put me down! m.s.'
ratbəḳ-əm > *rátəbḳəm* 'they m. ran alongside e.o.'
aḳarfəd-əm > *aḳárəfdəm* 'they m. turned over'

In the case of CVCCVC-CVC strings, pre-suffix syncope and epenthesis result in surface CCC clusters, as in (9):

(9) Epenthesis: CVCCVC-CVC strings
ḥatrək-ki > *ḥátərkki* 'we [dual] moved'
ratbəḳ-kəm > *rátəbḳkəm* 'you m.pl. ran alongside e.o.'
haḳfəd-ki > *háḳəfdki* 'bring us [dual] down!'
amaḳṣəd-kəm > *amáḳəṣdkəm* 'you m.pl. took a short cut'

Figures 10–12 illustrate epenthesis in the case of CVVCVC-CVC strings: *ʕágəbkəm* 'you m.pl. loved' (Figure 10), *aráḳədkəm* 'you m.pl. danced' (Figure 11) and *(əś)śə́səbkəm* 'your m.pl. leather satchel' (Figure 12).

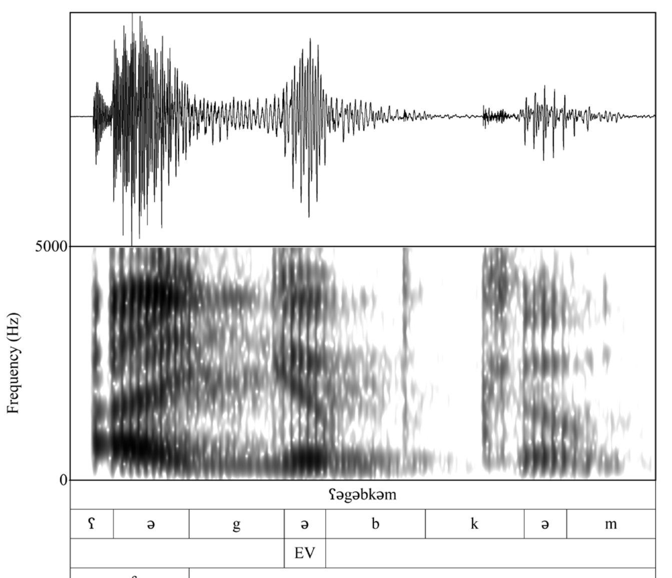

Figure 10: M068: *ʕágəbkəm* 'you m.pl. loved'

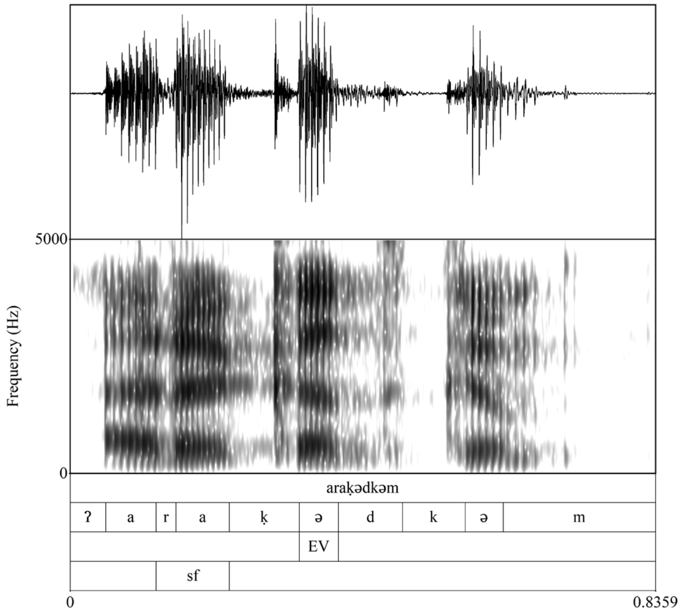

Figure 11: M001: *aráḳədkəm* ‘you m.pl. danced’

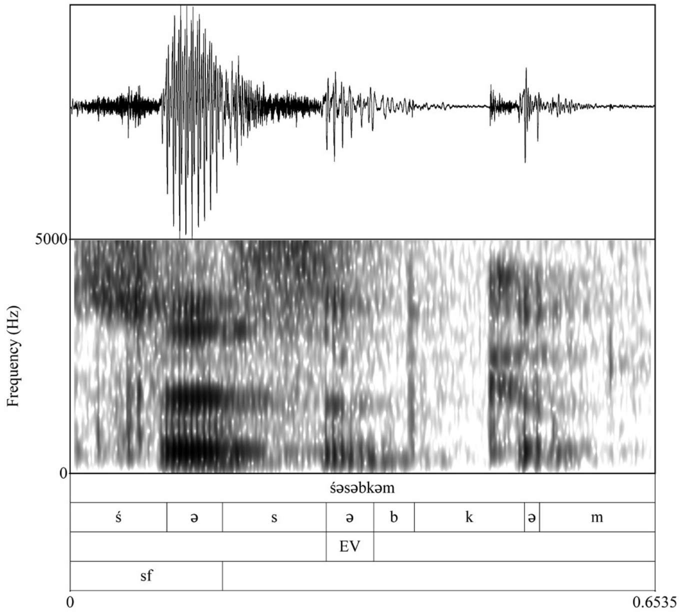

Figure 12: M068: *śə́səbkəm* ‘your m.pl. leather satchel’

Consider also epenthesis in Figure 13 *rīkəb-ki* > *rə́kəbki* from M083, an older (> 55 years at time of recording) male speaker from Rabkūt and a member of Bit Thuwār (sub-tribe Bit Khōr), who was recorded in 2011.

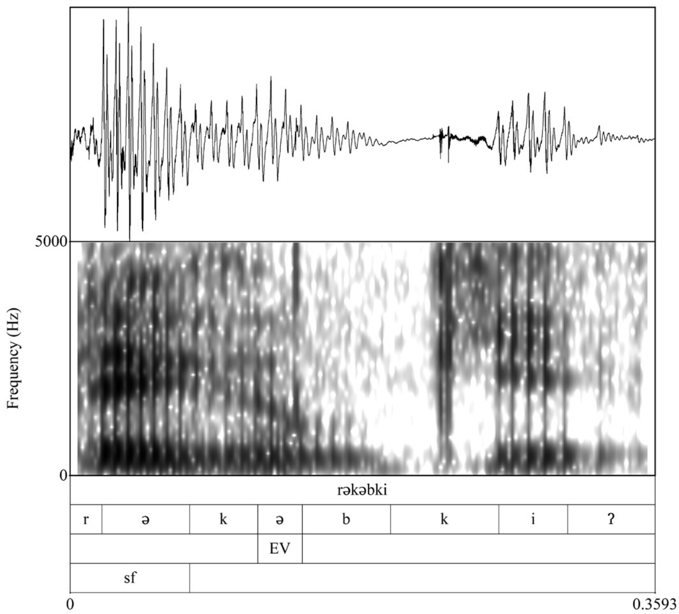

Figure 13: M083: *rə́kəbki* 'we two rode'

Figures 14 and 15 illustrate epenthesis in CVCCVC-(C)VC strings: *aḳárəfdəm* 'they m. turned over' (Figure 14) and *amáḳəṣdkəm* 'you m.pl. took a short cut' (Figure 15).

3.4 Speaker syllabification

In order to assess the psychological reality of epenthetic vowels, syllabification tasks were conducted with 1 female and 3 male Mehri speakers: syllabification was first demonstrated with English words (e.g. i.den.ti.fy, cau.tion); the target words were then presented in the vowelless Arabic-based script devised for the DEAMSA project and speakers were asked first to state how many syllables each word contained and then to pronounce each word slowly, dividing them into syllables. All speakers recognised the CVC string with the epenthetic vowel as a syllable (epenthetic vowel given in bold), syllabifying as in (10):

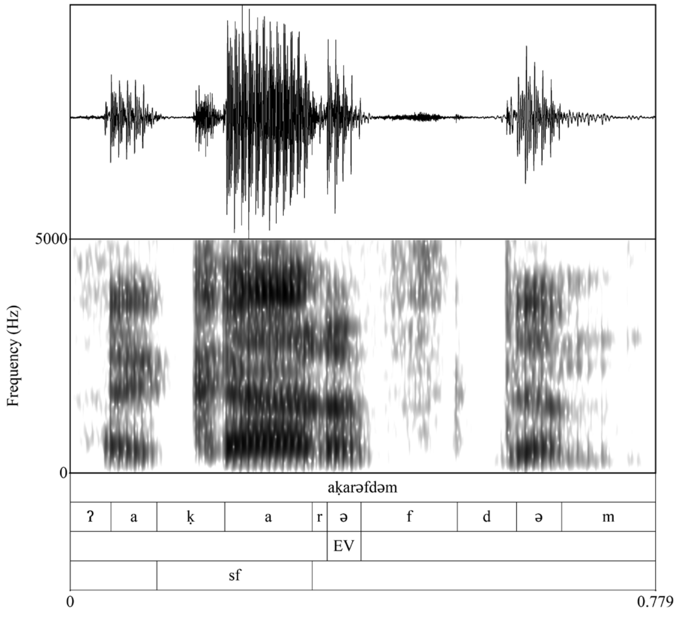

Figure 14: M001: *aḳárəfdəm* 'they m. turned over'

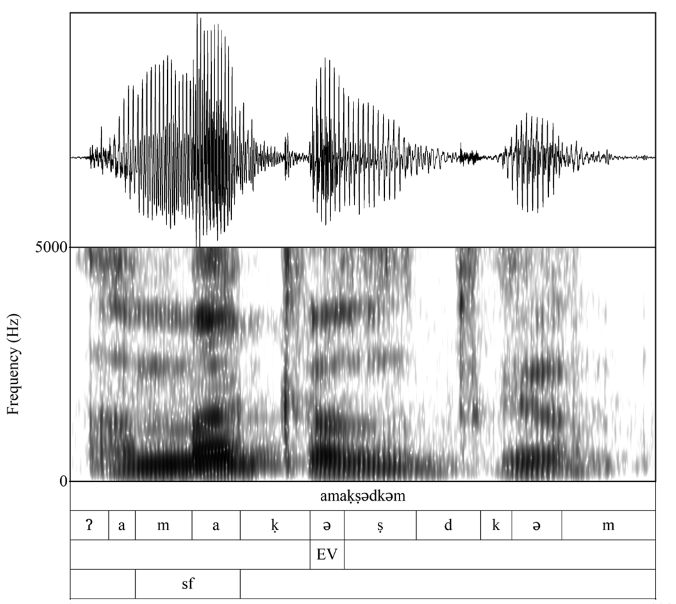

Figure 15: M079: *amáḳəṣdkəm* 'you m.pl. took a short cut'

(10) *a.ba.ḳəṣ́.kəm* 'your m.pl. running'
a.ʔa.gəz.kəm 'your m.pl. laziness'
a.ṯa.rəb.kəm 'your m.pl. stick'
(ś)śə.səb.kəm 'your m.pl. leather satchel'
rə.kəb.kəm 'you m.pl. rode'
a.ra.ḳəd.kəm 'you m.pl. danced'
a.ma.ḳəṣd.kəm 'you m.pl. took a short cut'

Figure 16 gives the syllabification of *a.ba.ḳəṣ́.kəm* 'your m.pl. running', produced by M001. The epenthetic vowel is highlighted.

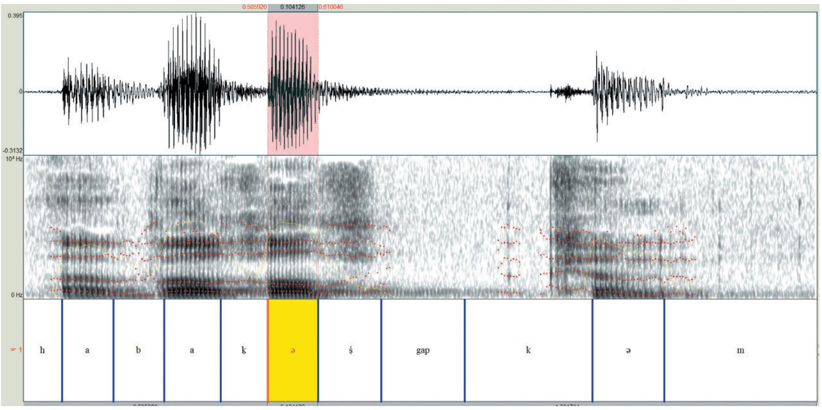

Figure 16: M001: *abáḳəśḳəm* 'your m.pl. running'

Note that while our analysis focusses on Central Dhofari Mehri, we assume that epenthesis operates in a similar way in at least some dialects of Mehri spoken within Yemen: word-list data collected from a Mehri speaker from the tribe of Bit al-Qumayri and resident in Ḥawf, shows epenthesis to the left of C_2 in all word types excepting *lībəs-kəm* > *ləbskəm*, as for some of our Central Dhofari Mehri speakers (3.2.5), where no epenthetic vowel is present in any tokens.

In Section 4, we examine intrusive vowels in Mehri and consider the distinction between epenthetic and intrusive vowels.

4. Intrusive vowels in Mehri

In the majority of work on Mehri following Johnstone (1975, 1987), word-initial consonant clusters in nouns, adjectives and basic verbs of the template CCVC are broken by an orthographic schwa for apparently etymological reasons, as in the following examples from

Johnstone (1987): *ṣəṭayṭ* 'pain', *ṯəbūt* 'to be, stand firm', *fərōḳ* 'to distribute guests over various houses in a community', *həḳawṭ* '[camel] to be lost'. By contrast, consonant clusters in cognate H-stem (causative) verbs with an initial 'breathed' consonant (Bendjaballah & Ségéral 2014, 'idle glottis') followed by an 'unbreathed' consonant are not broken by schwa according to these researchers: *ṯbūt* 'to make firm', *frōḳ* 'to frighten', *hḳawṭ* '[camel] to give birth'. Sima (2002, 2009), however, claims that CV syllables do not exist phonologically in the Mahriyōt variety of Mehri and transcribes initial consonant clusters without an orthographic schwa; Watson from the introduction to Sima (2009) transcribes initial consonant clusters without an intrusive schwa for both Mahriyōt and Dhofari Mehri; Liebhaber (e.g. 2011, 2015, 2020), describing the poetry of the Yemeni Mehri poet, Ḥājj Dākōn, transcribes word-initial consonant clusters, as in: *ṣrōma* 'now', *krēm* 'generous', *lṭīf* 'kind', *ġleḳk* 'I saw', *ġribk* 'you m.s. know', *kṯawr* 'to be knotted'. The consonant-cluster/intrusive vowel analysis for word-onset clusters in Central Dhofari Mehri, applied similarly by Kreitman (2008) for Hebrew,[13] by Fougeron & Ridouane (2008) for Berber,[14] and by Al-Aqlobi (2020) for Bisha and Makkan Arabic, is motivated by five principal factors: native-speaker intuitions, optionality and variable duration of intrusive vowels, biomechanical factors, and the presence of intrusive vowels across word-internal strings. We examine each of these factors in turn. Within biomechanical factors, we examine the role of laryngeal categories, sonorancy, place order and manner of articulation.

4.1 Native-speaker intuitions

Native speakers writing Mehri in Arabic-based vocalised script typically transcribe initial clusters with a *sukūn* over the initial consonant—a diacritic for Arabic script indicating no vowel following a consonant. In syllabification tasks, while native speakers identify a string with an epenthetic vowel as a syllable, as seen above, they do

[13] The Modern Hebrew transitional vowel, as described by Kreitman, is under 30ms, like the typical intrusive vowel in Mehri (though not before sonorants or after gutturals, when it is longer). 'The transition, if it exists, never exceeds 30ms. for all speakers, suggesting that it is too short to be a vowel.' (Kreitman 2008, 169).

[14] For Berber, Fougeron & Ridouane (2008, 441) describe 'schwa-like elements … [that] derive acoustically from a specific coordination between adjacent consonants.'

not identify, and appear to be unaware of, intrusive vowels.[15] Words such as *bkoh* 'to cry', *yəbṯūṯ* 'he disseminates' and *yəġśawṣ́* 'he winks' are syllabified as *bkoh*, *yəb.ṯūṯ* and *yəġ.śawṣ́* respectively with no attention paid to any intrusive vowel. We believe the cognitive lack of recognition of intrusive vowels is partly a manifestation of a strong tendency, also seen in Arabic, to avoid overlapping closures of the kind that in English result in place-of-articulation assimilations (cf. Ranjous 2009).[16] As in Arabic, place-of-articulation assimilations are rare in Mehri, except where they involve initial coronal nasals or /r/ plus coronal.

4.2 Optionality and variable duration of intrusive vowels

Intrusive vowels are optional (Hall 2006, 391), and cross-linguistically whether or not an intrusive vowel is realized and its duration in a particular context differs across speakers, across contexts and across speech rates (cf. Heselwood et al. 2015). The optionality of intrusive vowels and their variation in duration was observed in our data for Central Dhofari Mehri. Figure 17 illustrates *ṭwayl* 'long' produced by M001, which lacks an intrusive vowel in the initial consonant cluster. Other speakers may produce an intrusive vowel in this context.

Where intrusive vowels are produced, they are typically shorter in duration, lower in intensity and less vowel like than epenthetic vowels in the same consonantal context, as noted by Kreitman (2008) for Modern Hebrew.[17] Figure 18 illustrates *hṣ́awr* 'green' produced by M001 with an intrusive vowel of c. 18ms.

Word-initial consonant clusters in our data frequently, but not invariably, exhibit longer intrusive vowels compared to the same sequences in word-medial and word-final positions. This is to be expected for reasons of perceptual recoverability (Marslen-Wilson 1987; Chiteron et al. 2002): word onsets are potential utterance

[15] Phonology tells us that two identical phonetic strings may be interpreted differently at the phonological level by speakers of different languages (Hall 2006, 394). In Japanese, for example, where vowels are devoiced between voiceless consonants, Japanese speakers perceive a vowel between /s/ and /k/ in the form *siku* 'to lay out' where English speakers typically do not (Barry Heselwood, p.c.).

[16] Thanks to Barry Heselwood (p.c.) for this observation.

[17] The length of intrusive vowels is variable, however, depending on the nature of the consonants within the cluster (as predicted by Hall 2006, 391). As we see below, post-guttural/pre-sonorant clusters typically attract longer intrusive vowels; front–back place sequences typically attract shorter, or no, intrusive vowels in comparison to back–front sequences.

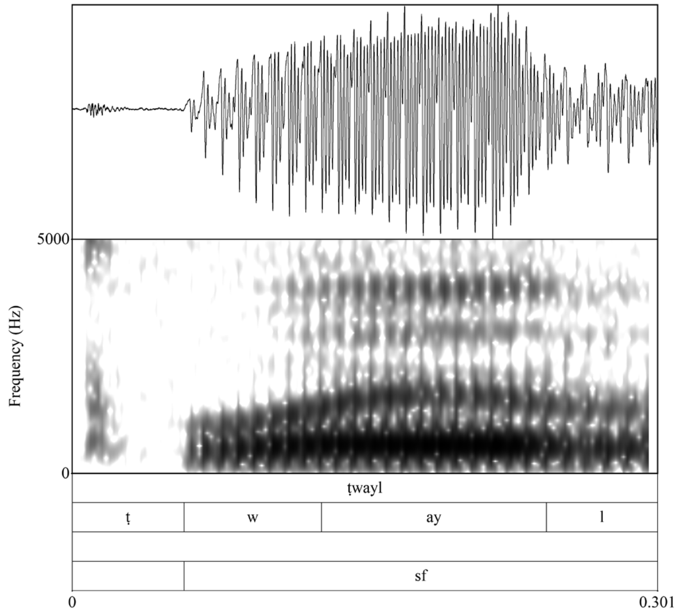

Figure 17: M001: *ṭwayl* 'long'

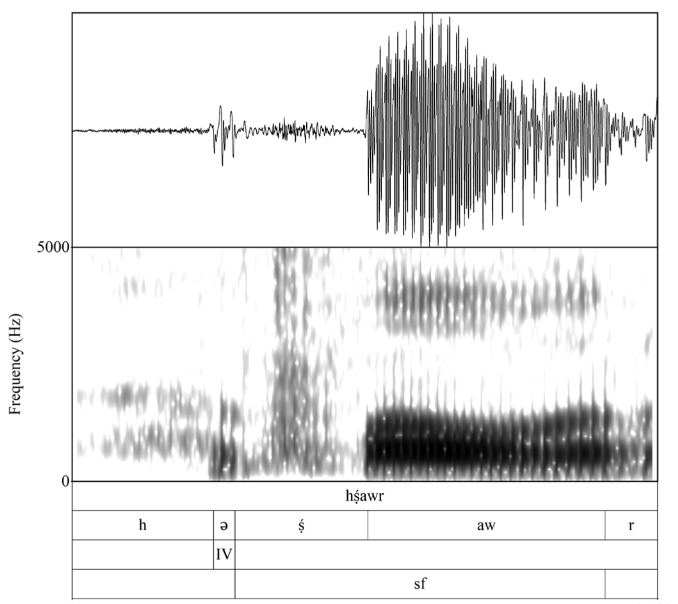

Figure 18: M001: *hṣ́awr* 'green'

onsets, and utterance-initial sequences of plosives provide no formant transition cues from a preceding vowel into either C_1 or C_2, with transitions only available during the release of C_2 into the following vowel (Chiteron et al. 2002). Cross-linguistically, onset clusters are thus found to exhibit less coarticulation, resulting in lower overlap than coda clusters or heterosyllabic clusters (e.g. Hardcastle 1985 for /kl/ versus /k#l/; Byrd 1996 for English onset clusters) such that intrusive vowels are predicted to be longer word-initially than in other positions (Chiteron et al. 2002; Alsubaie, in prep.).[18] The duration of intrusive vowels in our data also decreases the more syllables there are in the phonological phrase, as found cross-linguistically (e.g. Plug, Shitaw & Heselwood 2019); in Figures 19–21, the IV between /b/ and /d/ decreases from 24ms in *bdóh*, 15ms in *yəbdáh* with *yəbdáh bīs* showing no IV.

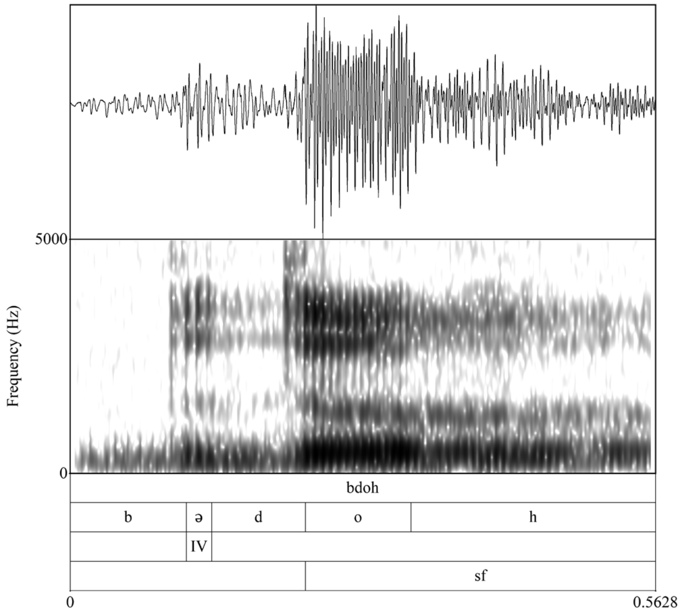

Figure 19: M001: *bdóh* 'to lie'

[18] For Georgian, Chiteron et al. (2002) show 'in word-internal sequences, C2 onset occurs on average soon after the achievement of C1 target, after only 5% of the C1 constriction interval, whereas in word-initial sequences C2 onset occurs much later (after an average of 82% of the interval).'

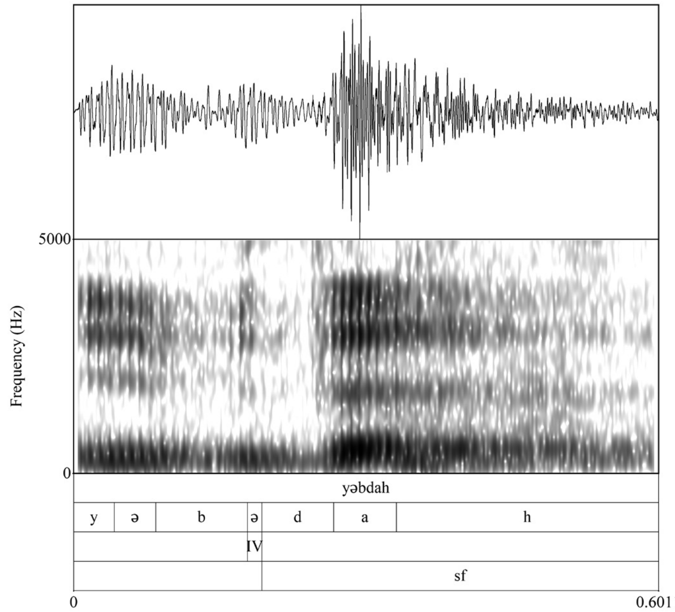

Figure 20: M001: *yəbdáh* 'he lies [subj]'

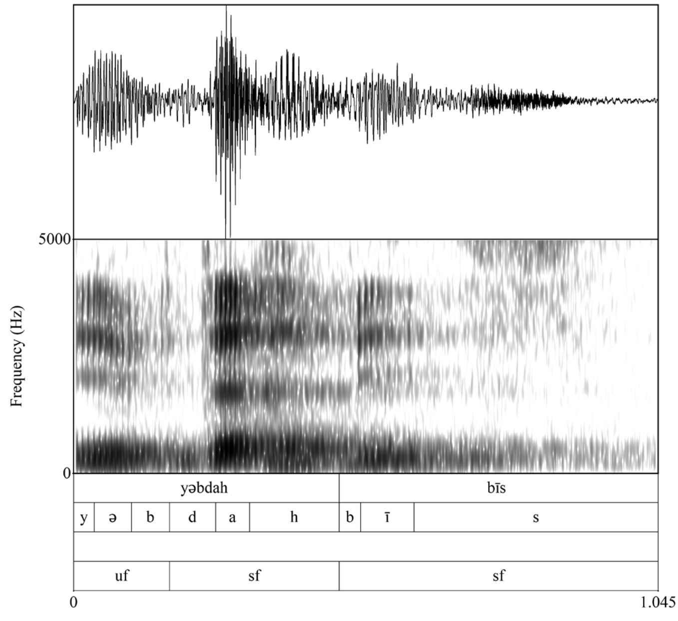

Figure 21: M001: *yəbdáh bīs* 'he lies about her [subj]'

4.3 Biomechanical factors

Biomechanical factors conspire with perceptual recoverability to constrain the degree of overlap within clusters according to several factors: heterorganic sequences are predicted to exhibit more frequent and longer intergestural lag than homorganic sequences (e.g. /rb/ versus /rt/); sequences involving sonorants or gutturals are predicted to exhibit longer intergestural lag than obstruent–obstruent sequences (Hall 2003); and front–back (labial–dorsal and interdental–dorsal followed by labial–coronal) clusters are predicted to exhibit shorter intergestural lag than back–front (dorsal–coronal or dorsal–labial) clusters (Byrd 1996; Yip 2012, 2013; Alsubaie, in prep.). We have already seen in section 3.2.5 that morphologically concatenated $C_1C_2C_3$ clusters frequently lack an epenthetic vowel when C_1 is a front plosive, /b/, and C_2 a plosive.

In Central Dhofari Mehri, whether or not an intrusive vowel is realized within a cluster depends on laryngeal categories, sonorancy, place order and manner of articulation. In the case of clusters of 'breathed' consonants, intrusive vowels are almost never realized.

4.3.1 Sonorancy

There are two cluster types in which the intrusive vowel is invariable and predicted to be longer: obstruent–sonorant clusters, (see Figure 27, *həklóh*), and clusters involving an 'unbreathed' guttural /ġ/ or /ʕ/[19] in either position, or an initial 'breathed' guttural fricative /ḥ, h, x/ followed by an 'unbreathed' consonant.[20] For Mehri, this is due to the predilection of sonorants for a left-hand vocalic support (Bendjaballah 2017; Dufour 2016, 53, 180 for Shehret), on the one hand, and the predilection of gutturals for a right-hand vocalic support (Bendjaballah 2017), on the other.[21] The predilection of

[19] /ʕ/ is rarely realized as [ʕ] in word-medial clusters in Central Dhofari Mehri. The few examples we have are common Arabic loanwords, such as *maṭʕam* 'restaurant' and *yaʕni* 'that is to say', all of which exhibit an intrusive vowel to the left of /ʕ/ in the case of C/ʕ/ clusters and to the right of /ʕ/ in the case of /ʕ/C clusters. This phenomenon is also found in Shehret, which maintains /ʕ/ in all positions.

[20] Hall (2003, v, 27) shows a partial implicational hierarchy, whereby some languages exhibit vowel intrusion when a guttural occurs in the cluster but not in the case of (other) sonorants, and other languages exhibit vowel intrusion in the case of both gutturals and (non-guttural) sonorants.

[21] 'Unbreathed' gutturals thus behave both as sonorants, in attracting a left-hand vocalic support, and as gutturals, in attracting a right-hand vocalic support. This observation is supported by the phonetics where Mehri word-medial /ġ/ and /ʕ/ frequently display vocalic-like formant structure, as illustrated in Figure 23. In an

gutturals to take a right-hand vocalic support can also lead to occasional vowel intrusion within 'breathed' clusters, where the initial consonant is pharyngeal /ḥ/, as in: *yəḥ[ə]sūs* 'he feels [ind]' and *yəḥ[ə]sēs* 'he feels [subj]'. Gutturals in word-medial position frequently exhibit sonorant-like formant structures: /ʕ/, where produced, has a typical sonorant-like structure; /ġ/, typically unvoiced in utterance-initial position, is most often fully voiced and may have sonorant-like structure in word-medial position; /h/ is almost invariably realized with breathy voice word-medially; and /ḥ/ is frequently at least partly voiced word-medially. An example of a sonorant-like medial /ġ/ is given in Figure 22.

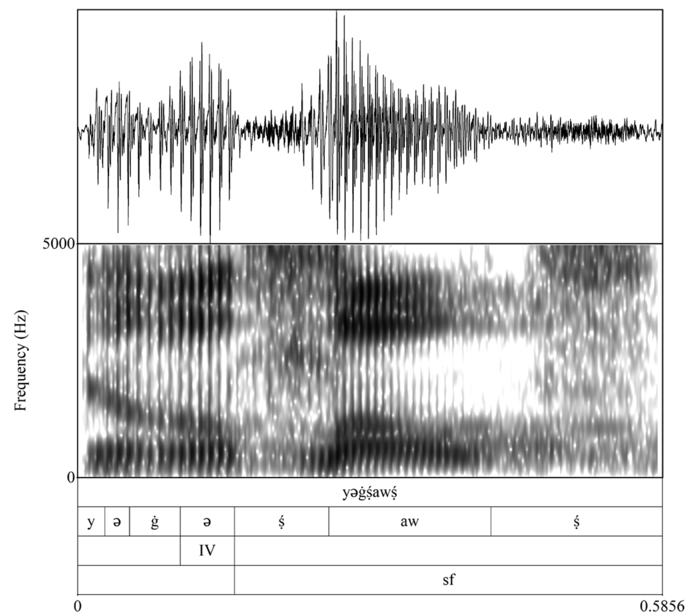

Figure 22: M001: *yəġṣ́awṣ́* 'he winks'

Intrusive vowels are almost invariably produced adjacent to the rhotic /r/ when realized as a tap, even in homorganic sequences such as /rt/, /rd/, /rś/ where these do not result in retroflexion.

4.3.2 Place order

Cross-linguistically, front–back consonant clusters are less likely to exhibit IVs and where they do, the IV is predicted to be shorter than

analysis of acoustic and laryngographic data, Heselwood describes /ʕ/ in some varieties of Arabic as a 'tight approximant' (Heselwood 2007).

in back–front clusters (Byrd 1996; Yip 2012, 2013; Alsubaie, in prep.). Because the tongue is not involved in its production, initial /b/ for various speakers produces [+voiced][+voiced] (i.e. ‘unbreathed’ ‘unbreathed’) and [+voiced][-voiced] (i.e. ‘unbreathed’ ‘breathed’) clusters without an IV when followed by a consonant further back than /b/;[22] [+voiced][-voiced] clusters have previously been argued not to exist in languages of the world (cf. Vennemann 1988, 2012; Lombardi 1995; but see Kreitman 2008, 2010 for Modern Hebrew, Khasi and Tsou, and Ridouane & Fougeron 2011 for Tashlhiyt Berber and Moroccan Arabic). Such front–back onset clusters include *bdóh* ‘to lie’, *bdīw* ‘they m. lied’, *bgūd* ‘to chase’, *bzūl* ‘to turn off’, *bkóh* ‘to cry’, *bxāṣ* ‘to be in pain’ and *bhēṣ́* ‘to be surprised’. Where no intrusive vowel is realized, initial /b/ may be realized with full, partial or no voicing before a ‘breathed’ consonant. Compare Figures 23 and 24 of *bxaṣk* ‘I am in pain’ produced by a young female speaker (M073): in Figure 23, /b/ is pre-voiced; in Figure 24, /b/ is voiceless.

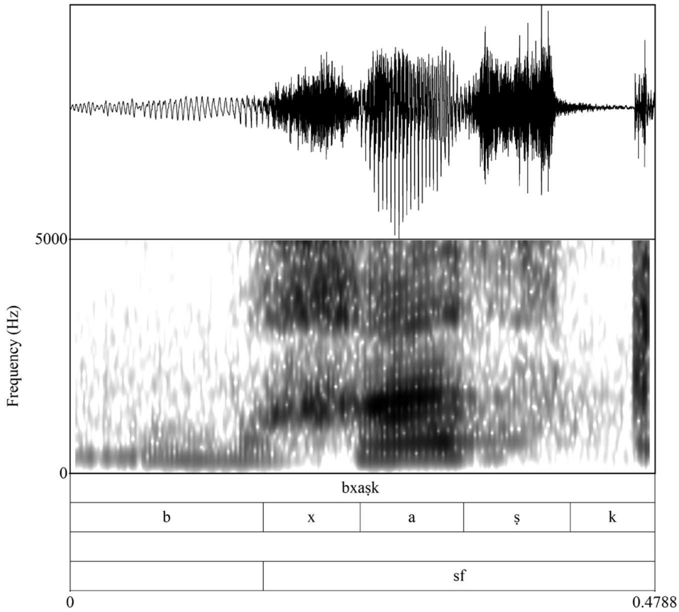

Figure 23: M073: *bxaṣk* ‘I am in pain’

[22] As a back–front cluster, /b/ followed by an interdental frequently does take an intrusive vowel in our data, as we see below for word-medial clusters.

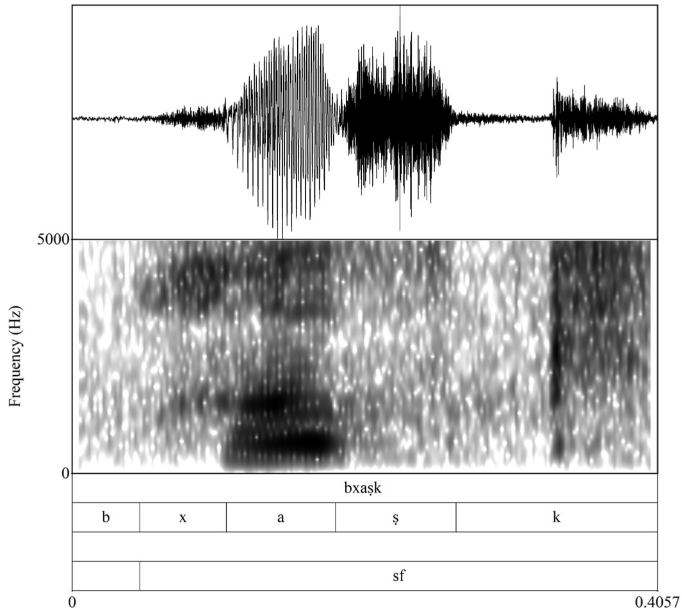

Figure 24: M073: *bxaṣk* ‘I am in pain’

In Figure 25, /b/ in *bkóh* ‘he cried’, produced by a young male speaker from the tribe of Bit Ḳhōr now based in Rabkūt, shows light pre-voicing with some voicing of the initial part of /k/.

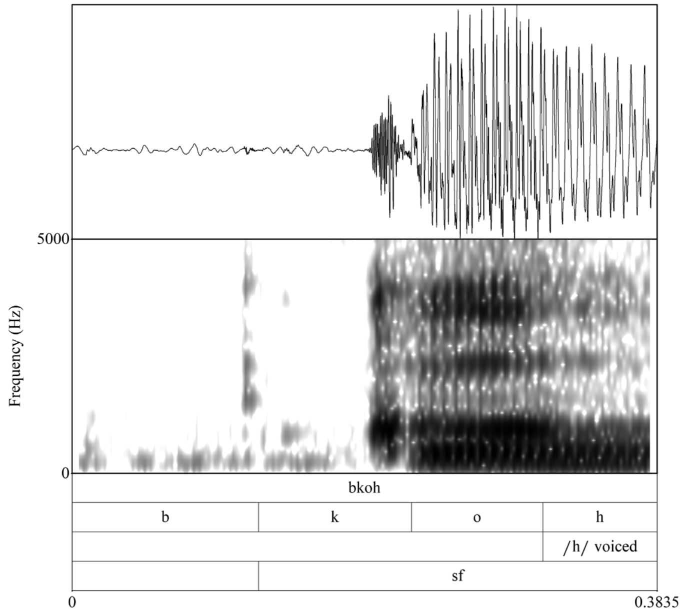

Figure 25: M003: *bkóh* ‘he cried’

4.3.3 Manner of articulation

Onset clusters of heterorganic fricatives or fricative–plosive sequences differing in laryngeal categories may similarly be realized without an intervening vocalic-like element, particularly in a front–back sequence: for example, where the initial fricative is labio-dental /f/, as in *fṣ̌āl* 'plenty', *fṣ̌āṣ̌* 'press m.s.!' and *fṭāṭ* 'spots', or interdental /ḏ/, as in *ḏkūr* [place name]. Consider Figure 26 of *fṣ̌āl* 'plenty' produced by J001.

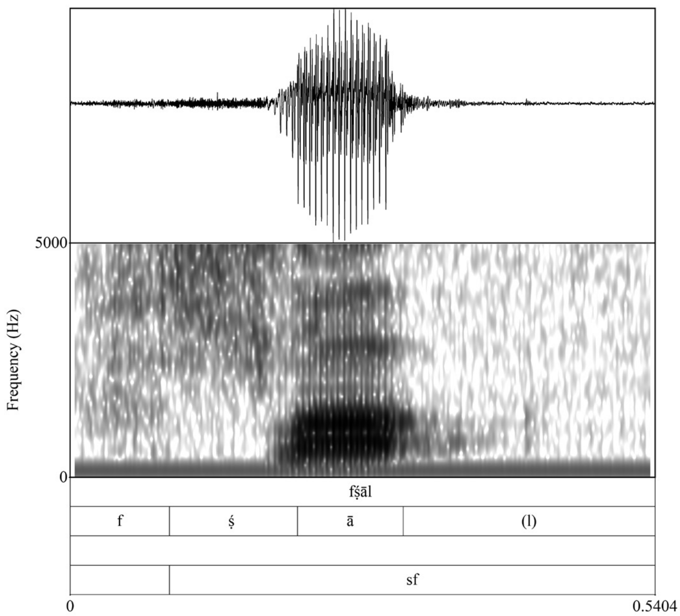

Figure 26: J001: *fṣ̌āl* 'plenty'

4.4 Intrusive vowels across word-internal strings

While strings of 'breathed' consonants are regularly realized without an intervening vowel-like element, strings of heterorganic consonants differing in laryngeal category and strings of heterorganic 'unbreathed' consonants are often realized with an intrusive vowel irrespective of syllable structure and position in the word (cf. Dufour 2016, 37 for Shehret). Thus, the medial and final consonantal strings in words such as *yəġmūm* 'he is unkind', *yəṣbūb* 'he pours', *yəḥlūl* 'he lives', *ṯəbrək* 'I/you m.s. became broken', *śərġək* 'I/you m.s. desired', *kərmaym* 'hill', *ʕə́gbək* 'I/you m.s. love', *ḥarḳ* 'hot', *raḳb* 'ledge',[23] words which are generally transcribed without schwa breaking the cluster (e.g. Johnstone 1987; Simeone-Senelle 1997, 2011; Rubin 2010, 2018), are frequently realized with audible and acoustically visible intrusive vowels.[24] Figure 27 of *həklóh* 'to bring livestock back to the homestead in the evening'[25] produced by J001 has an intrusive vowel of around 31ms.

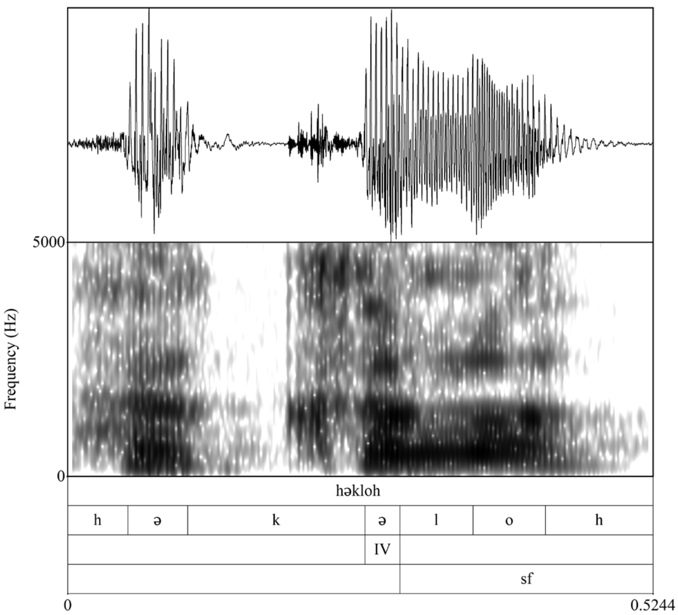

Figure 27: J001: *həklóh* 'to bring livestock back to the homestead in the evening'

Shared laryngeal category conspires with manner and place of articulation to determine whether or not an intrusive vowel is produced: word-medial sequences of heterorganic 'breathed'[26] or 'unbreathed' plosive–fricatives frequently fail to exhibit an intrusive vowel, while heterorganic 'unbreathed'–'breathed' plosive–fricative sequences are typically broken by intrusion. A comparison of *həḳṣawm* 'to spend the hot part of the day', *həḳṣəmk* 'I/you m.s. spent the hot part of the day', *yəḳṣawṣ* 'he cuts', *yəgzēm* 'he swears [subj]', *yəbzēl* 'he turns off [subj]' and *abṣār* 'the dawn' with *həḳśūr* 'to misbehave',

[26] As shown in 3.2.3, 'breathed' clusters also fail to induce epenthesis.

yəḳsūs 'he tells a story', *yət̠fawf* 'they m. float', *śəḳfīf* 'steep slope', *nəbḥəm* 'they m. barked' and *d̠ə-yəbt̠awt̠* 'they m. disseminate' show the former set with medial 'unbreathed' plosive–fricative clusters to exhibit no intrusive vowels and the latter set with medial 'unbreathed'–'breathed' plosive–fricative clusters to exhibit intrusive vowels.

4.4.1 'Unbreathed' clusters

For speakers within our database, all tokens of *həḳṣawm*, *həḳṣəmk*, *yəḳṣawṣ* and *abṣār* which exhibit word-medial 'unbreathed' clusters are realized without an intrusive vowel, as exemplified in Figures 28–31.

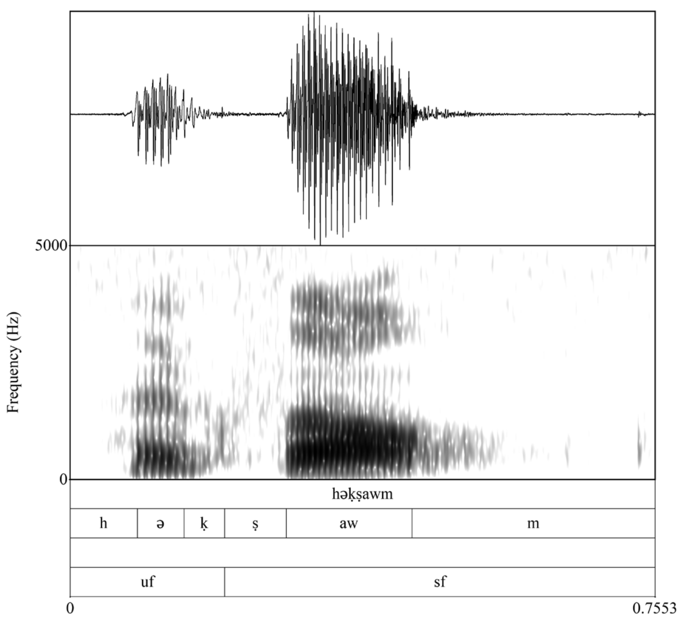

Figure 28: M001: *həḳṣawm* 'to spend the hot part of the day'

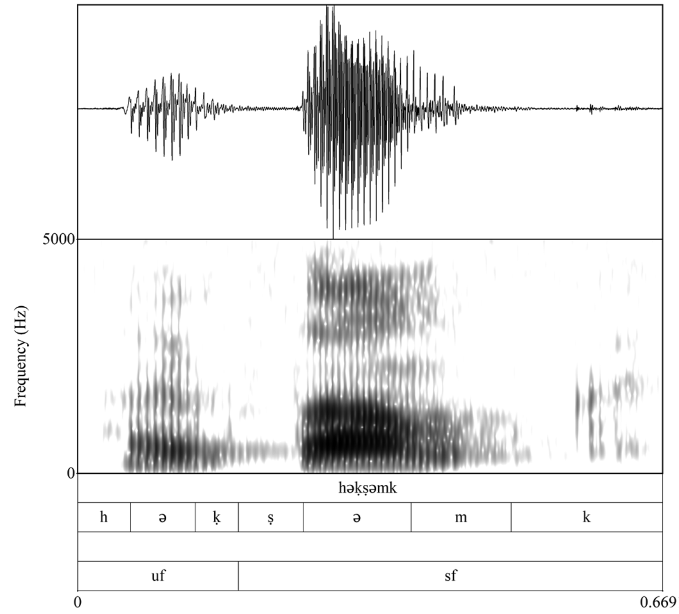

Figure 29: M001: *həḳṣəmk* 'I/you m.s. spent the hot part of the day'

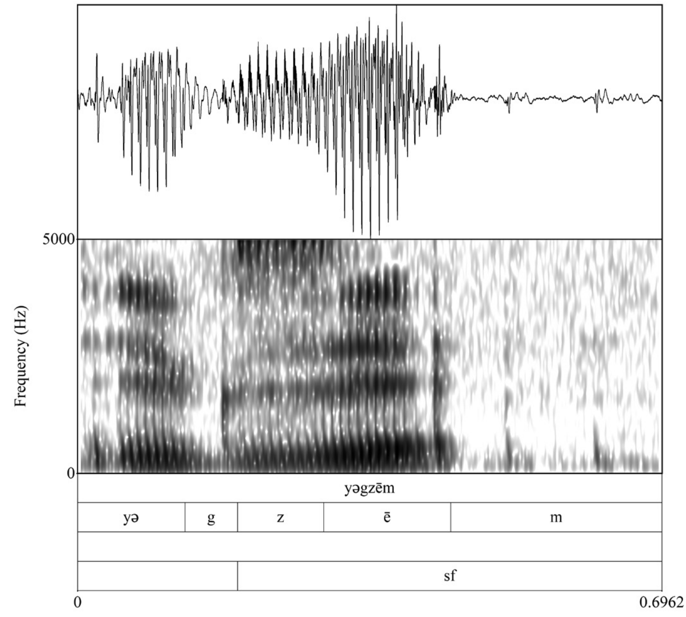

Figure 30: M001: *yəgzēm* 'he swears [subj]'

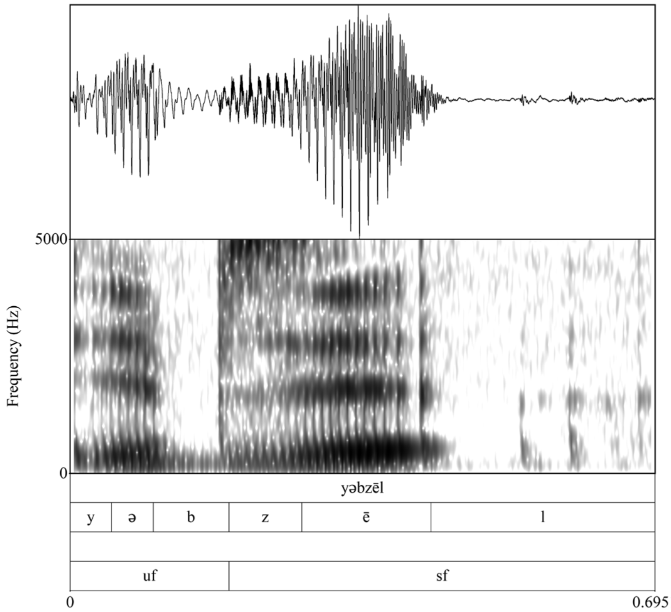

Figure 31: M001: *yəbzēl* 'he turns off [subj]'

4.5.2 'Unbreathed'–'breathed' clusters

All tokens of *həḳśūr*, *yəḳsūs*, *yəṭfawf*, *śəḳfīf*, *nəbḥəm* and *ḏə-yəbṯawṯ* 'they m. disseminate', which exhibit 'unbreathed'–'breathed' clusters, are realized with an intrusive vowel, as exemplified in Figures 32–37. Note that this is even the case when the 'breathed' C_2 is realised with voicing, as in Figures 34–37.

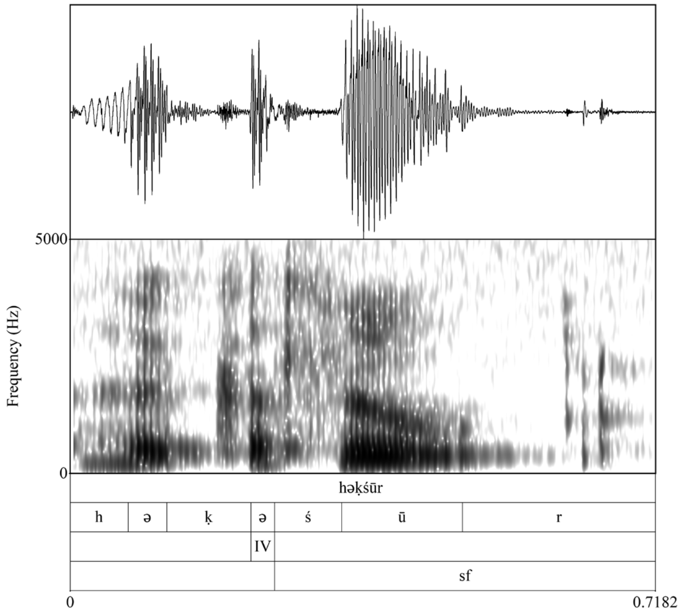

Figure 32: M001: *həḳśūr* 'to nag; to misbehave'

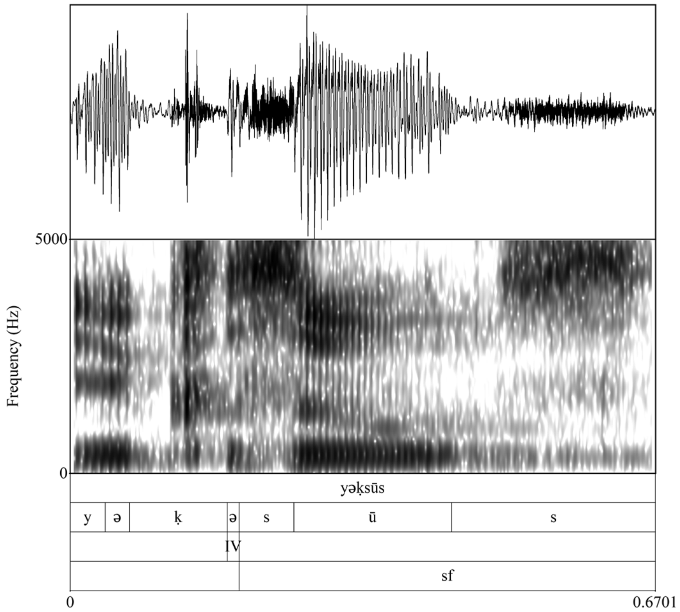

Figure 33: M001: *yəḳsūs* 'he tells a story'

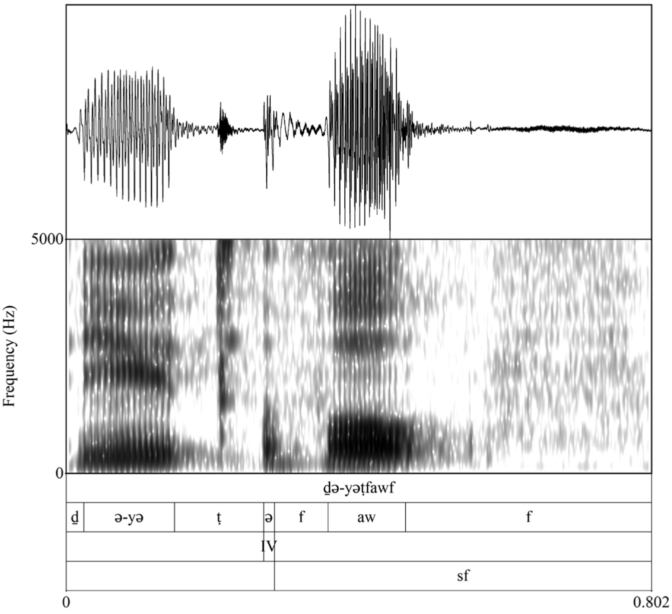

Figure 34: M068: *ḏə-yəṭfawf* 'they m. are floating'

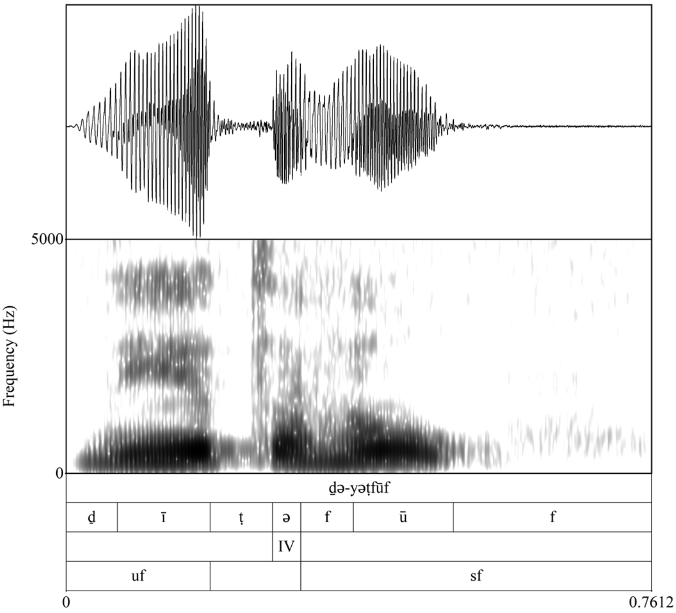

Figure 35: M026: *ḏə-yəṭfūf* 'he is floating'

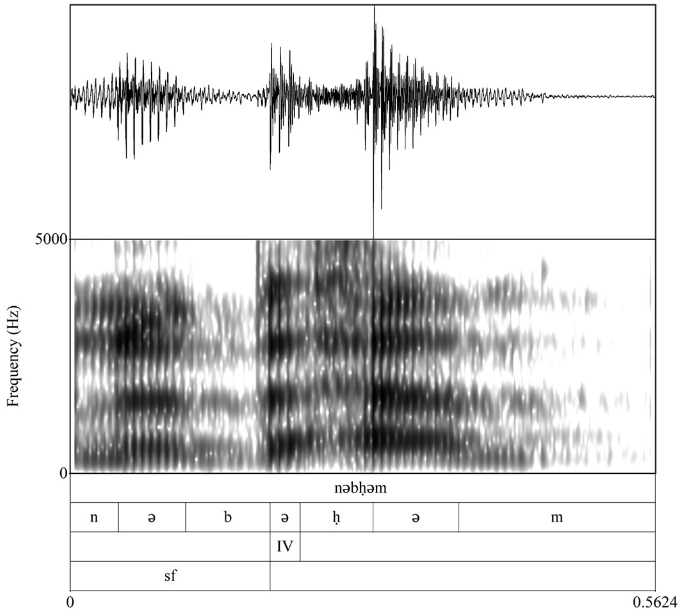

Figure 36: M001: *nəbḥəm* 'they m. barked'

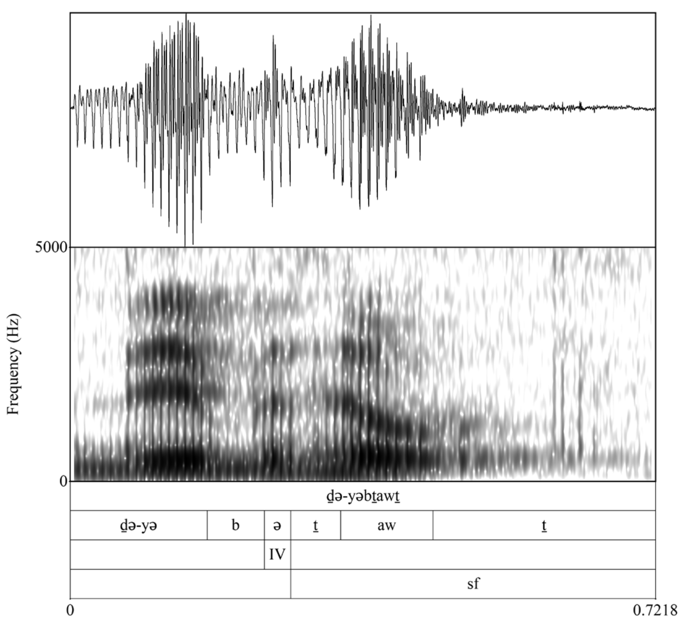

Figure 37: M001: *ḏə-yəbṯawṯ* 'they m. disseminate'

4.5.3 Place order

Heterorganic fricative–plosive sequences almost invariably exhibit IVs among our speakers where C_2 is /b/, irrespective of the laryngeal category of C_1, supporting the predilection for IVs in the case of back–front sequences, as in *yəṣbūb* 'he pours', *yəhəṣ́būb* 'he heats up' and *yəśbūb* 'he goes up'; front–back heterorganic fricative–plosive sequences, by contrast, fail among several, but not all speakers to exhibit IVs, again irrespective of the laryngeal category of either consonant. Compare Figure 38 of *yəṣbūb* in the back–front order with Figures 39–42 of *əfṭāṭ* 'spots', *təṣkákəh* 'you m.s. shut it m. [subj]' and *yəśḳawḳ* 'he splits' in the front–back order.

Individual speaker variation is observed in the realization of an IV between a 'breathed' fricative and 'unbreathed' plosive in the front–back place order, as we see by comparing the tokens of *yəśḳawḳ* 'he splits' above and below. M001 and M026 in all our data fail to produce an IV in this position, while M068 and M028 regularly produce an IV in careful speech. Figure 42 shows M068's production of *yəśḳawḳ* with an IV of around 20ms.

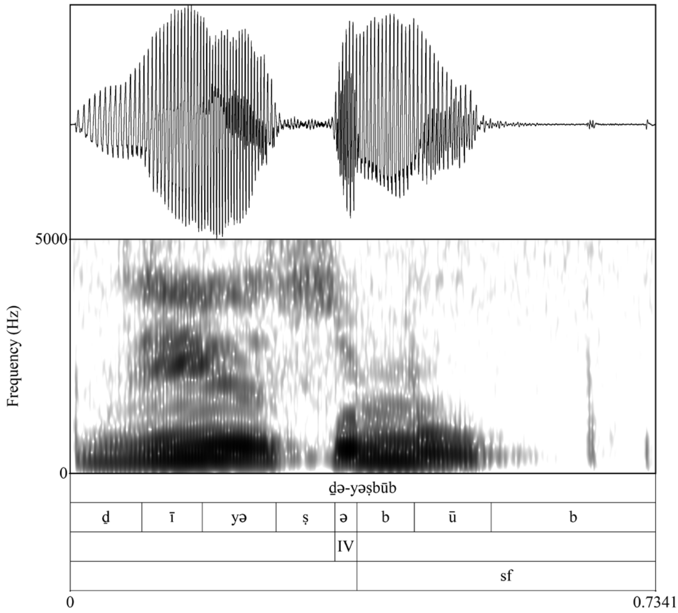

Figure 38: M026: *ḏə-yəṣbūb* 'he is pouring'

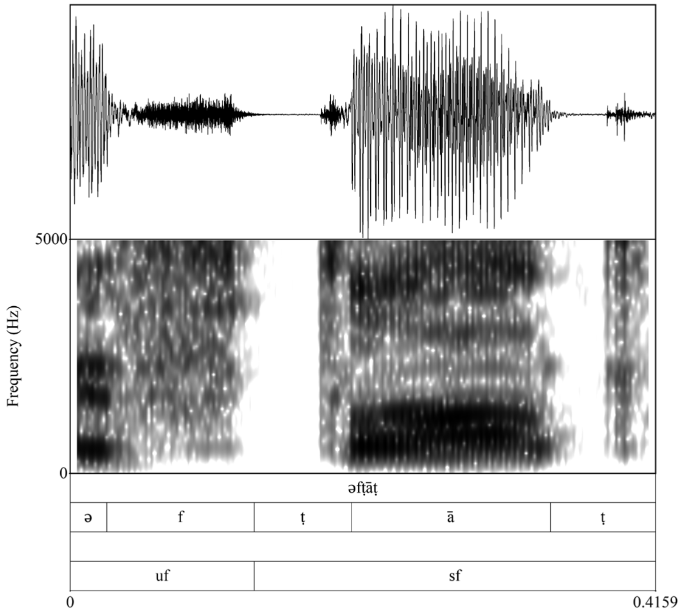

Figure 39: M026: *əfṭāṭ* ‘spots’

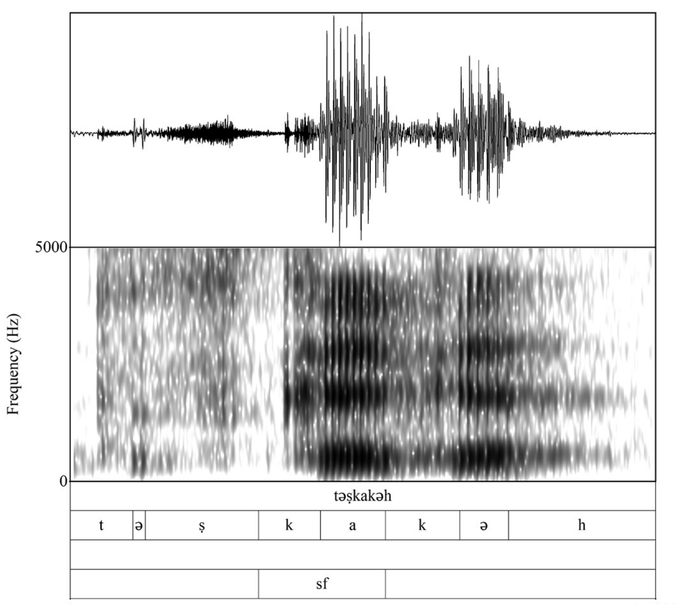

Figure 40: M001: *təṣkákəh* ‘you m.s. shut it m. [subj]’

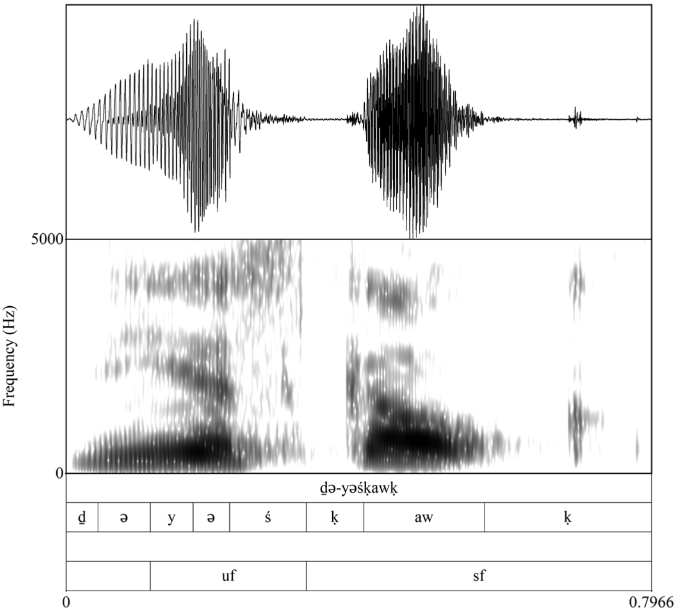

Figure 41: M026: *ḏə-yəśḳawḳ* ‘he is splitting’

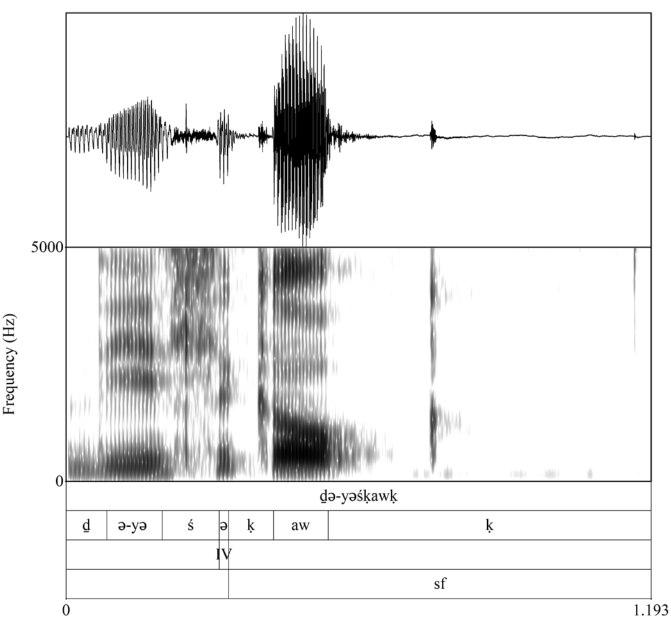

Figure 42: M068: *yəśḳawḳ* ‘he splits’

4.5.4 Manner of articulation and laryngeal categories

In terms of clusters of fricatives or of plosives, 'breathed' clusters are extremely rarely broken by an IV, as found by Kreitman (2010, 177) for Modern Hebrew and Ridouane & Fougeron (2011) for Tashlhiyt Berber (although 'breathed' clusters are sometimes separated by an unstressed vowel, as we see in Figure 27 *həklóh*). 'Breathed'–'unbreathed' fricative clusters are frequently not broken by an IV where C_1 is labio-dental /f/ due to the predilection of front–back clusters to attract shorter, or no, IV, as in *yəfṣ̌awṣ̌* 'he presses' and *yəfṣ́awṣ́* 'he escapes'; guttural–non-guttural clusters such as *yəxzáh* 'he refuses [subj]' invariably take an IV; other 'breathed'–'unbreathed' clusters are variable. 'Breathed'/'unbreathed' fricative and fricative/plosive clusters invariably take an IV where the fricative is an 'unbreathed' guttural, as exemplified in *yəġṣ́awṣ́* 'he winks', *lətġəm* 'they m. killed' given in Figures 43 (repeated from Figure 22) and 44, and the Arabic loanword, *maṭʕam* 'restaurant', and are otherwise variable.

'Unbreathed' plosive clusters typically fail to take an IV in the front–back place order, as in *abḳār* 'the cows', *yəṭḳawḳ* 'he/they m. knock', but typically take an IV in the back–front place order, as in *araḳbək* = *araḳ[ə]bək* 'your m.s. small cave', *yəṭbēx* = *yəṭ[ə]bēx* 'he cooks [subj]' and *ʕəgbək* = *ʕəg[ə]bək* 'I/you m.s. love'.

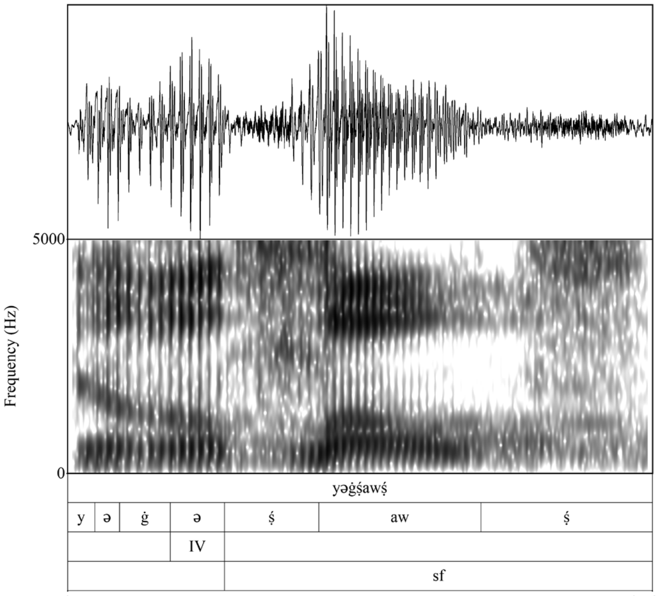

Figure 43: M001: *yəġṣ́awṣ́* 'he winks'

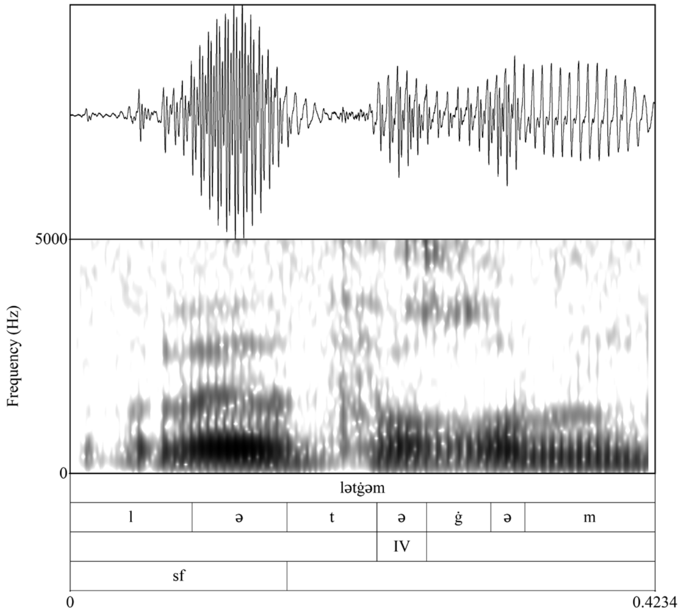

Figure 44: J001: *lətġəm* 'they m. killed'

4.6. Summary

Table 3 summarizes in terms of laryngeal categories, manner of articulation and sonorancy those sequences which according to our data invariably take IV (2), those which variably take IV (1), and those which never take IV (0). '-' in the table denotes gemination in case of -Br G and /r/ clusters. The Y-axis denotes C1, the X-axis C2. To limit the complexity of the table, place order is not taken into account here. The following abbreviations are used:

Br	'breathed'
-Br	'unbreathed'
F	'fricative'
G	'guttural'
P	'plosive'
/r/	/r/
S	'non-rhotic sonorant'

Table 3. Predictability of IVs by sequence

C1 C2	Br P	Br F	Br G	-Br P	-Br F	-Br G	/r/	S
Br P	0	0	0	1	1	2	2	2
Br F	0	0	0	1	1	2	2	2
Br G	0	0	0	2	2	1	2	2
-Br P	1	1	1	1	1	2	2	2
-Br F	1	1	1	1	1	2	2	2
-Br G	2	2	1	2	2	-	2	2
/r/	1	1	1	1	1	2	-	2
S	0	0	0	0	1	2	2	1

5. Statistical analysis

Intrusive vowels vary greatly in duration, depending on laryngeal categories, sonorancy, manner and place of articulation, number of syllables in the word, speech rate and the individual; however, on average, we predict that stressed vowels will be longer than unstressed, epenthetic and intrusive vowels, and that epenthetic vowels will be longer than intrusive vowels, as illustrated in Figure 45 *śə́səbkəm* 'your m.pl. leather satchel' pronounced by M001 (see Figure 4 in Heselwood et al. 2015), from left to right, stressed /ə/ (86ms), epenthetic [ə] (38ms), intrusive [ə] (22ms) and unstressed /ə/ (51ms).

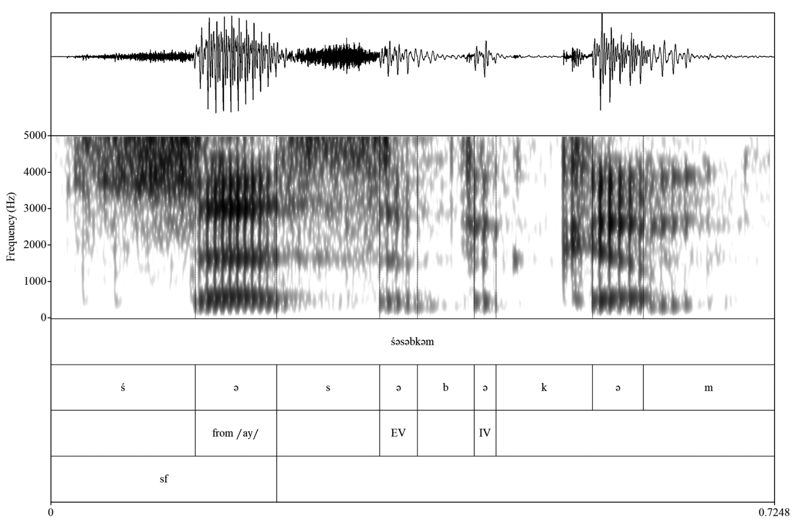

Figure 45: M001: *śə́səbkəm* 'your m.pl. leather satchel'

For the statistical analysis, there were a total of 5448 [ə] in the dataset. [ə] vowels that function as the definite article (N=194) and as prosthetic vowels (N=36) were excluded from this analysis as the focus was on word-medial vowels. A total of 5218 vowels were analyzed (1197 stressed lexical, 417 stressed derived, 2348 unstressed lexical, 930 intrusive and 326 epenthetic). All intrusive and epenthetic vowels were unstressed.

A linear mixed-effect regression model was built using the lme4 (Bates et al., 2015) and lmerTest (Kuznetsova et al., 2017) packages in R (R Core Team, 2021) and RStudio (RStudio Team, 2021). Vowel duration in milliseconds was the dependent variable, with vowel type (stressed lexical, stressed derived, unstressed lexical, intrusive and epenthetic) as the fixed factor and participant, word and recording device as random intercepts.[27] The model with a random slope for participants failed to converge. Dummy coding was used with stressed lexical vowels as the baseline level. The duration of all vowel types was significantly shorter than that of stressed vowels. A Tukey post-hoc test using the emmeans package (Lenth 2021) revealed that the duration of vowel types was significantly different from each other, except for the difference between unstressed lexical and epenthetic vowels, which only approached significance (Table 4).

Table 4. Result of pairwise comparisons of vowel type on vowel duration using a Tukey post-hoc test with the emmeans package.

Pairwise comparisons	Estimate	SE	df	*t*-ratio	*p*-value
stressed lexical - stressed derived	-22.74	1.424	5205	-15 .967	<.001
stressed lexical - unstressed lexical	5.61	0.969	5074	5.788	<.001
stressed lexical - epenthetic	8.60	1.447	5201	5.948	<.001
stressed lexical - intrusive	23.58	1.194	4856	19.741	<.001
stressed derived - unstressed lexical	28.35	1.098	4949	25.833	<.001
stressed derived - epenthetic	31.35	1.353	4820	23.166	<.001
stressed derived - intrusive	46.32	1.221	5043	37.931	<.001
unstressed lexical - epenthetic	3.00	1.134	5086	2.641	0.063
unstressed lexical - intrusive	17.97	0.796	5199	22.586	<.001
epenthetic - intrusive	14.98	1.278	5163	11.719	<.001

[27] Corresponding model code in R: lmer(duration ~ vowel_type + (1| participant) + (1| word) + (1| recording_device), data = data).

Stressed lexical vowels (M = 83.3, SD = 21.3) were significantly longer than stressed derived vowels (M = 75.2, SD = 16.2), which were longer than unstressed lexical (M = 55.3, SD = 24.3) and epenthetic vowels (M = 41.3, SD = 13.6). Epenthetic vowels were significantly longer than intrusive vowels (M = 31.9, SD = 14). Figure 46 shows the distribution of vowel duration for each vowel type and illustrates the pattern described above.

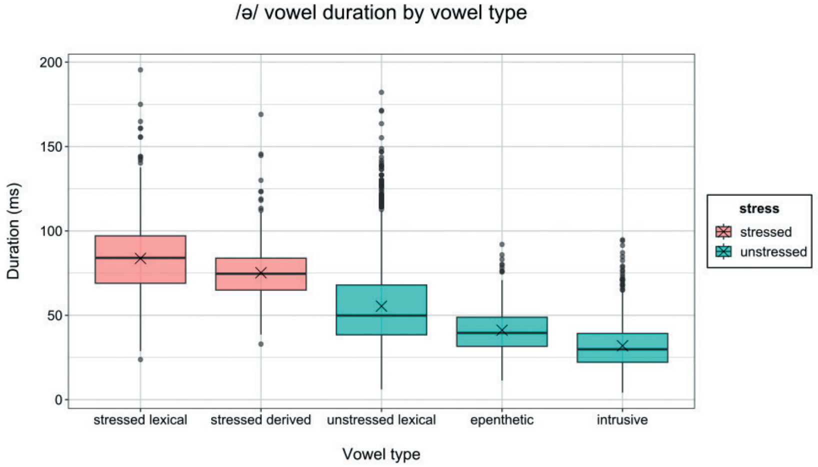

Figure 46: Boxplots showing vowel duration in milliseconds as a function of vowel type (stressed lexical, stressed derived, unstressed lexical, epenthetic, intrusive). Stressed vowels are shown in pink in the two boxplots on the left and unstressed vowels in blue in the three boxplots on the right. Black crosses represent the mean for each category.

To take into account word duration, a separate linear mixed-effect model regression and Tukey post-hoc tests were conducted on vowel duration divided by word duration, following the same methodology. The model results revealed a very similar pattern, but in this case the post-hoc comparison between unstressed lexical and epenthetic vowels was clearly not significant (Estimate = 0.00463, SE = 0.00214, df = 4939, *t*-ratio = 2.159, *p*-value = 0.1957). This suggests that the difference in duration between these two categories is not robust.

5.1. *Effect of surrounding consonants on intrusive vowels*

A separate analysis was conducted to investigate the effect of surrounding consonants on intrusive vowels (N = 930). No distinction was made between consonants across or within word boundaries. Given the role of sonorants and gutturals on the presence of IVs discussed in section 4, we predicted that IVs followed by a sonorant (N = 349) would be longer than IVs followed by an obstruent (N = 581); we also predicted that a preceding guttural (N = 127) would lengthen IVs, compared to IVs not preceded by a guttural (N = 803). A linear mixed-effect regression model was built to investigate the effect of following consonant class (obstruent vs. sonorant) and preceding consonant class (guttural vs. non-guttural) on IV duration. Random factors consisted of participant and word intercepts, following the first model.[28] Deviation coding was used for the two fixed factors in order to examine main effects. There was a significant effect of following consonant class, indicating that IVs followed by sonorants were significantly longer than those followed by obstruents (Table 5). This effect was modulated by a significant interaction.

Table 5. Results of linear mixed-effect model on IV duration.

	Estimate	Std. Error	df	*t*-value	*p*-value
Intercept	33.792	1.806	15.496	18.711	<.001
Following C	-6.539	1.917	262.872	-3.412	<.001
Preceding C	-2.674	1.911	263.405	-1.400	0.163
Following C* Preceding C	-12.881	3.833	264.114	-3.361	<.001

Post-hoc Tukey tests with the emmeans package showed that when followed by an obstruent, IVs are shorter when preceded by a guttural (Estimate = -9.12, SE = 2.66, df = 277, *t*-ratio = -3.422, *p*-value = <.001), than when they are not preceded by a guttural. However, a preceding guttural does not affect duration when IVs are followed by sonorants (Estimate = 3.77, SE = 2.78, df = 289, *t*-ratio = 1.353, *p*-value = 0.177). Figure 47 illustrates this pattern. IVs followed by obstruents when not preceded by gutturals are shorter (M = 26.9, SD = 10.8), compared to IVs followed by obstruents and preceded by gutturals (M = 34.3, SD = 10.9), IVs followed by sonorants and preceded by gutturals (M = 36, SD = 12) and IVs followed by sonorants and not preceded by gutturals (M = 39.5, SD = 16).

[28] Corresponding model code in R: lmer(duration ~ following_consonant_class*preceding_consonant_class + (1| participant) + (1| word), data = filter(data, vowel_type == "IV")).

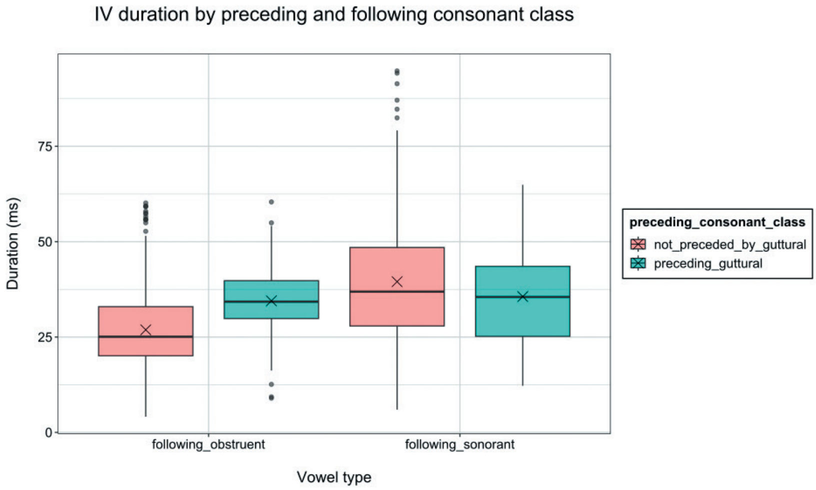

Figure 47: Boxplots showing IV duration in milliseconds as a function of surrounding sonorant class (followed by obstruent, followed by sonorant). IVs preceded by gutturals are shown in blue on the right for each pair of boxplots and IVs not preceded by gutturals in pink on the left for each pair of boxplots. Black crosses represent the mean for each category.

6. Conclusion

This paper has presented a descriptive and quantitative analysis of epenthesis and vowel intrusion in Central Dhofari Mehri. Epenthetic and intrusive vowels exhibit the properties predicted by Hall (2006, 391), provided in the introduction and repeated below.

Properties of phonologically visible inserted vowels (epenthetic vowels):

a. The vowel's presence is not dependent on speech rate;
b. The vowel repairs a structure that is marked, in the sense of being cross-linguistically rare.

Properties of phonologically invisible inserted vowels (intrusive vowels):

a. The vowel generally occurs in heterorganic clusters;
b. The vowel is likely to be optional, have a highly variable duration, or disappear at fast speech rates;
c. The vowel does not seem to have the function of repairing illicit structures. The consonant clusters in which the vowel occurs may be less marked, in terms of sonority sequencing, than clusters which surface without vowel insertion in the same language.

In Mehri, both epenthesis and vowel intrusion are affected to differing degrees by the phonotactics of the language. However, while epenthesis is motivated principally by constraints on syllable structure, vowel intrusion is motivated wholly by the phonotactics of the language. We show, contra Johnstone (1987) and others (e.g. Rubin 2010, 2018), that excepting cases in which C_1C_2 form an indivisible unit, epenthesis in $C_1C_2C_3$ clusters in Central Dhofari Mehri occurs to the left of the unsyllabified consonant (C_2), like in Arabic VC-dialects (Kiparsky 2002), resulting in stress opacity. In terms of vowel intrusion, for an intrusive vowel to surface, at least one of C_1 or C_2 needs to be 'unbreathed' (cf. Ridouane & Fougeron 2011 and Ridouane & Cooper-Leavitt 2019 for Tashlhiyt Berber). Intrusive vowels are highly variable in duration, depending on the consonantal environment, position in the word, number of syllables in the word, rate of speech and the individual. Impressionistically, epenthetic vowels also vary in duration depending on consonantal context, speech rate and the individual. Within our database, however, intrusive vowels exhibit an overall duration that is significantly shorter than that of epenthetic vowels. One crucial difference between epenthetic and intrusive vowels lies in the fact that epenthetic vowels are recognized as syllable heads by native speakers, while intrusive vowels are not.

Impressionistic work with Shehret speakers suggests that intrusive vowels are acoustically present, but, as for our Mehri speakers, are not recognised as syllable heads by native speakers. Beyond that, the relationship between epenthesis and vowel intrusion has yet to be explored in other MSAL or, indeed, in many other Semitic languages, and would prove a fruitful area for future research. Our examination of surrounding place and manner of articulation on vowel duration in this paper is exploratory. Further research is needed to see whether the results shown here can be replicated in an investigation of further data from Mehri and the other MSAL. An exploration of reasons behind surrounding consonants affecting vowel duration may be shown to have implications for phonetic theory more generally.

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