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The structure of vowelless verbal roots in Tashlhiyt Berber

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Abstract

At the phonological level, Tashlhiyt Berber features remarkably long strings of consonants with no intervening vowels [5, 22]. Past research on the topic has investigated the structure of syllabic constituents, suggesting that in spite of its acknowledged complexity, the language favours syllable structure with simple onsets [4, 5, 23]. In this preliminary work, we upturn the traditional idea of evaluating syllable formedness, and provide a feature-based analysis of vowelless verbal roots. Methodologically, the study draws on bottom-up approaches to phonotactics [16, 17] which lead to the formulation of new preferences on the basis of a qualitative and quantitative description of segments forming clusters. The identification of such preferences has the potential of revealing phonological properties which motivate the unique patterning of consonant sequences in the language.

Index Terms: Tashlhiyt Berber, phonotactic preferences, distinctive features, verbal roots

1. Introduction

Berber (or Amazigh) is an Afro-Asiatic group of languages native to inhabitants of North Africa. Tashlhiyt Berber, the language investigated in this contribution, is spoken in Morocco over a large area including the Anti-Atlas and High-Atlas mountains as well as the southern plains. The language, which has been well documented on both phonetic and phonological grounds (see [20, 21] for a review), is well known to have syllables composed entirely of consonants (C) with no intervening vowels (V), and whole utteances reaching more than 30 adjacent consonants [22]. Vowelless syllables permit any C in the nuclear position, including the least sonorous voiceless stops (e.g. /k/ forms the peak of the /tk/ syllable in /tk.mi/ 'she smoked'). A fundamental aspect of this analysis concerns constraints on complex onsets and codas (complex codas are allowed only if they consist of a geminate). As a result, a CCC sequence is parsed either as a monosyllable if the second consonant is a nucleus (e.g. /srs/ 'put') or as a disyllable (e.g. /r.zm/ 'open', where both /r/ and /m/ are nuclei).

The complexity of consonant sequences in a language naturally follows from a high C to V ratio [12]. With 64 consonants and only three core vowels /i a u/ in Tashlhiyt [21], the C/VQ amounts to 21:1. Given this proportion, the remarkable character of Tashlhiyt phonotactics should be not only unsurprising, but also expected. Accordig to [12], the Tashlhiyt syllable is classified as complex on par with languages belonging to, for instance, Slavonic and Germanic families. While these systems feature complex clusters at syllable or word margins (e.g. /ʑʥbwo/ in Polish *źdźbło* 'grass stalk', or /heʁpst/ in German *Herbst* 'Autumn'), in Tashlhiyt /f/ 'to give', /kks/ 'to take off', and /tbdrtnt/ 'she mentioned them' represent mono- or poly-syllabic words. Therefore, in this contribution we provide insights into preferred phonological structure of vowelless verbal roots.

2. Modelling of phonotactics

The principle of sonority has been traditionally applied in the evaluation of phonotactics. Sonority corresponds with the degree of articulatory constriction, and ensuing loudness of a sound. That is, plosives (e.g. /p t k/), articulated with a complete closure in the vocal tract, and vowels (e.g. /i e a/), characterized by a large aperture, are located at the least and most sonorous extremes of the hierarchy, respectively. A universally preferred syllable structure should exhibit a rise in sonority from the margins towards a vocalic peak, as specified by the *Sonority Sequencing Generalization* (SSG) [24].

However, the structure of vowelless sequences cannot be adequately captured solely by the SSG. Tashlhiyt words such as /nss/ 'deflate' and /rkks/ 'hide' pose major problems for the sonority principle which requires a phonological vowel in the computation of cluster formedness. According to [4, 5], the procedure applied in the selection of syllabic nuclei and core syllables (onset nucleus) relies crucially on relative sonority relationships between segments within a sequence, with more sonorous segments being preferred as syllable peaks. In addition to the sonority requirements, the competition between segments is further determined by two structural conditions: the prohibition of onsetless syllables (except in postpausal position) and the avoidance of complex onsets and codas (unless complex codas dominate a geminate). These requirements have priority over sonority in assigning syllable structure to strings of segments.

In the present analysis, we investigate the structure of verbal roots beyond the principle of sonority, and make use of several phonological properties in cluster description. The analysis offers insights into statistically prevalent patterns of featural organization of Tashlhiyt vowelless sequences, leading to the formulation of phonotactic preferences. The idea that sonority can be decomposed into a number of criteria was explored in [16, 17]. A systematic comparison of Polish, English and German phonotactics has demonstrated that place, manner and voice features have different weight in different systems. Statistically derived weight has its conceptual base in the principle of phonological activity, according to which a feature is seen as active if it plays a role in phonological patterning and regularities [2, 25]. Parameters with greater weight have greater discriminatory power. A similar idea was pursued in [3], who demonstrate that some features are universally more favoured in the formation of phonemic systems than others. This paper aims at finding such parameters for vowelless sequences in Tashlhiyt.

The subject literature reports on phonotactic constraints in Tashlhiyt. [1] discusses place constraints which prohibit (non)adjacent labials in a consonant sequence, and coronals / dorsals with the same manner of articulation. But the data analyzed were limited to segments bounded by morphological boundaries. [10] provided a brief description of some of the constraints accounting for the distribution of sonorants and obstruents in 220 verbs (i.e. CC, CCC, and CCV). Focusing on

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the segmental composition of triconsonantal roots, it was argued that specific structural and distributional constraints shape the internal organization of the root. For example, each verbal triconsonantal root contains at least one sonorant. In addition, root consonants are subject to co-occurrence restrictions that are captured in terms of sonority-sensitive dependency relationships between the most sonorous segment in the root and the neighboring segments: a sonorant is thus often preceded by an obstruent. Moreover, if two sonorants are contiguous, then the second sonorant is necessarily more sonorous.

3. Study

The objective of the paper is to propose an analysis of Tashlhiyt phonotactics, based on descriptive statistics. The complete list of cluster-words is described in terms of 13 parameters. The selection of parameters is inspired by previous analyses of phonotactically elaborate languages in [16, 17], which make use of up to 19 parameters (P) related to cluster length and phonological complexity. Here, we examine only those parameters that can be seen as exponents of sonority, in line with numerous sonority hierarchies that have been proposed (see [18] for an overview).

3.1. Data

The data was extracted from the dictionary of 1068 verbal roots [14]. 41% of the roots are vowelless, giving rise to the list of 436 words analysed in this paper. The words, composed of one to five consonants, were manually transcribed using the IPA convention. To keep the analysis simple, secondary articulation was not included. Labialized and pharyngealized sequences such as /gʷn/ 'sleep', /sˤχtˤ/ 'condemn' and /qʷndˤ/ 'sulk' were specified only in terms of their basic phonological form, namely /gn/, /sχt/ and /qnd/.

The dataset includes items displaying lexically contrastive gemination, a salient property of the Tashlhiyt phonological system. Every consonant in the language has a geminate counterpart found in all word positions, e.g. /ʃʃ/ 'eat', /qqrqb/ 'hit', /sʒʒl/ 'record', /qzz/ 'look'. Following a commonly accepted view (see [9] for a survey), Tashlhiyt geminate consonants are represented as two prosodic positions or X-slots associated with one melodic unit. That is, the form /fss/ 'be quiet' is analyzed as a sequence of three consonants at the skeletal level, but the last two segments (/ss/) are linked to one feature bundle at the melodic level. Our verb list includes some rarely attested geminates, such as pharyngeals (e.g. /sħħr/ 'bewitch'), glottals (e.g. /tˤhhr/ 'clean up'), and pharyngealized /z/ word-finally (e.g. /fzˤzˤ/ 'chew up'). It is important to note that all the roots in our dataset are fully-specified words, which can be produced in isolation as well-formed meaningful utterances. All these words correspond to the perfective conjugation (2nd person singular).

3.2. Methodology

The procedure was adapted from [16, 17], where phonotactic preferences are derived from the lexicon, and where statistical methods are used in determining the explanatory power of parameters. The qualitative analysis consists in specifying each segment in terms of phonological features pertaining to the place of articulation, manner of articulation and voice. The description is based on the IPA classification of the Tashlhiyt consonant inventory [21].

The consonants relevant for the present analysis are given in Table 1, where the following labelling convention of the places of articulation is assumed; L - labial, C - coronal, D - dorsal, P - palatal, Ph - pharyngeal, G - glottal. To keep the analysis simple, secondary articulation was not included. What is more, labialized and pharyngealized segments /kʷ gʷ qʷ χʷ ʁʷ tˤ dˤ sˤ zˤ ʃˤ ʒˤ nˤ rˤ lˤ/ are not treated as contrastive (see section 3.1.).

Table 1: *Classification of consonants in Tashlhiyt.*

	L	C	D	P	Ph	G
Stop	b	t d	k g q			
Fricative	f	s z ʃ ʒ	χ ʁ		ħ ʕ	h
Nasal	m	n				
Rhotic		r				
Lateral		l				
Glide	w			j		

The quantitative analysis involves calculating the number of clusters adhering to a particular parameter pattern, captured by percentages. The percentages are further transformed into percentage scores, expressed by a numerical value ranging from 0 to 1. For instance, if the proportion of obstruents and sonorants word-initially equals 348 : 88 (total=436 items), words starting with [+obstruent] score 0.8 (=80%), while words starting with [-obstruent] score 0.2 (=20%) for parameter 2 which specifies the manner of articulation of the word-initial C. Parameters are next ranked, revealing properties which contribute the most to cluster discrimination in the language.

3.3. Results

Below, we discuss the summary of the results for parameters P1-P13 calculated for 436 vowelless verbal roots. Each table reports on the number (No) and percentage (%) of words with a particular pattern.

3.3.1. Cluster structure

Following the classification of the syllable structure in [12], a two-member cluster is a mild violation of the CV universal, while longer strings are regarded as moderately or extremely complex. Interestingly, vowelless verbal roots in Tashlhiyt are largely represented by CCC sequences (83%), which points to their substantial degree of complexity. It must be emphasized that more than 40% of the verbal roots (in particular CCC) contain geminates (see section 3.3.3.).

Table 2: *Parameter 1: Cluster length.*

P1	No	%
2: CC	53	12
3: CCC	360	83
4: CCCC	21	5
5: CCCCC	2	0

3.3.2. Manner of articulation

To detect prevalent manner patterns, we use a broad division of consonants into sonorants (S) and obstruent (O)s, and specific manner types employed in sonority hierarchies such as [6, 7, 8, 26]. The analysis is based on five manner parameters. Firstly, P2 and P3 specify the word-initial segment. The results summarized in Table 3 demonstrate that the vast majority of words starts with an obstruent (80%), particularly a fricative (49%). In the class of sonorants, the number of words decreases with an increase in articulatory opening. That is, the more sonorous the consonant, the less likely it is to occur in C1.

Table 3: *Parameters 2-3: Word-initial C.*

P2	No	%	P3	No	%
Obstruent	348	80	Fricative	215	49
			Stop	133	31
Sonorant	88	20	Nasal	49	11
			Rhotic	22	5
			Lateral	14	3
			Glide	3	1

A parallel description is provided for word-final position in P4 and P5. Table 4 shows that no prevalent pattern can be established; the distribution of obstruents and sonorants is comparable (54% to 46%), similarly to specific manner types. Fricatives are favoured, although they occur finally only in 28% of the words under scrutiny. What is more, there is a ban on verbal roots ending in glides.

Table 4: *Parameters 4-5: Word-final C.*

P4	No	%	P5	No	%
Obstruent	235	54	Fricative	123	28
			Stop	112	26
Sonorant	201	46	Rhotic	89	20
			Nasal	55	13
			Lateral	57	13

P4 and P5 provide insights into word margins only. Therefore, we introduce another parameter, which allows us to generalize over the distribution of manner classes within a word. P6 outlined in Table 5 traces the opening of the vocal tract from C1 rightwards in terms of obstruents and sonorants. Four patterns can be distinguished: an *increase* defines a rise in sonority from the first to the last segment (e.g. OS, OSSS), a *decrease* specifies a fall in sonority (e.g. SSO, SOO), while *plateau* words are composed of an identical type of segments (e.g. SS, OOOO). A *mixed* category is proposed for sequences in which the above gestures are combined (e.g. OSSO, OOSSO).

Table 5: *Parameter 6: Sonority profile.*

P6	No	%
Increase	155	36
Decrease	47	11
Plateau	72	16
Mixed	162	37

Generally, 64% of the verbal roots in Tashlhiyt display a universally disfavoured sonority profile, represented by decreasing, plateau and mixed articulations. The most exploited patterns involve OSO (106 items) and OOS (105 items), constituting 48% of the dataset. OO, OSO and OSOO are preferred among CC (43%), CCC (29%) and CCCC (33%) groups, respectively. Among the *plateau* clusters, verbs composed of sonorants only are almost inexistent. Only one CC and two CCC roots are attested (/ml/ ‘show’, and /rwl/ and /lwr/ which are variants of the same verb meaning 'escape'). This suggests the existence of a distributional constraint that requires the presence of at least one obstruent in consonant-only verbal roots.

3.3.3. *Place of articulation*

Although the manner features are largely used in the computation of cluster formedness, some sonority hierarchies additionally include the place of articulation by keeping vowels of different height distinct (e.g. [7], [8], [26]). In order to complete the description of Tashlhiyt verbs, we introduce four place parameters, based on the classification in Table 1.

We start with the description of word margins in terms of general place categories. P7 and P8 correspond with broad manner features captured by P2 and P4. Table 6 shows that coronal segments are generally favoured but the presence of dental and post-alveolar consonants is more pronounced word finally (62%). Articulations which involve the rear part of the mouth and laryngeal cavity are dispreferred. Voiceless and voiced aryepiglottal fricatives /H ʕ/ are rare, while voiced glottal fricative /h/ is obsolete at word edges.

Table 6: *Parameters 7-8: Word-initial and final C.*

P7	No	%	P8	No	%
Labial	81	19	Labial	87	20
Coronal	211	48	Coronal	270	62
Dorsal	101	23	Dorsal	51	12
Pharyngeal	39	9	Pharyngeal	25	6
Glottal	4	1	Glottal	3	0

As was noted earlier, geminates are common in Tashlhiyt verbal roots, and can occur in all word positions. In terms of sonority, adjacent identical segments are classified as plateau articulation. Table 7 shows that almost half of the words contains one geminate: 30 CC, 139 CCC and 12 CCCC. The data also features verbs containing two geminates, namely /ffnzzr/ 'stare', and /qqllq/ 'get angry'. The most favourable gemination context is word-medial (136 items), followed by initial (42 items) and final (5 items).

Table 7: *Parameter 9: Presence of a geminate.*

P9	No	%
Present	181	42
Absent	255	58

Apart from gemination, we are also interested in constraints which hold over clusters containing segments with the same place specification. Parameter 10 is motivated by the phonotactic constraint which bans adjacent labials. As an extension of the *Obligatory Contour Principle* (OCP) [11, 13], contrbutions by [15, 27] suggested that the place OCP effect also governs homorganic (i.e. not totally identical) consonants. Since only neighbouring coronals are admitted in Tashlhiyt, P10 is used to investigate the manner classes of adjacent dental and post-alveolar segments. Note that coronal+coronal sequences are found in all word positions; initial /slm/ 'be muslim', final /kʷʃdˤ/ 'hurt', medial /ʁndf/ 'cheat'. Table 8 summarizes the results of the analysis.

Table 8: *Parameter 10: Shared place.*

P10	No	%
=place, ≠manner	174	40
=place, =manner	4	1
Unshared	258	59

Overall, 41% of verbal roots contain two adjacent coronals (=place). Although no preferred pattern can be formulated for P10 as such, a phonotactic constraint can be posited for the *=place* subgroup. That is, adjacent consonants with the same place specification should belong to different manner classes (≠manner). The only words with the same manner of articulation (=place,=manner) involve items with coronal fricatives such as /ʃʒʒʕ/ 'encourage', /sʒd/ 'bow down'. All of these verbs are loan words from Arabic.

3.3.4. Voice

Voicing properties are expressed by three parameters. Table 9 presents the results for P11 and P12, which determine voice specification at word edges. P13 summarized in Table 10 describes voicing of all consonants within words, for which three patterns can be proposed. Disregarding their length, words with *total* agreement are either uniformly voiced (e.g. /ʒmʕ/ 'gather', /ʁrbz/ 'mix up') or voiceless (e.g. /ks/ 'feed on', /sttf/ 'arrange'). Words with *no* agreement contain no adjacent segments with the same voice specification (e.g. /sʁ/ 'buy', /rkz/ 'dance'). Most words longer than CC exemplify a pattern of *partial* agreement, where at least one adjacent pair agrees in voicing (e.g. /krfs/, /kr/=no, /rf/=no, /fs/=total).

Table 9: Parameters 11-12: Word-initial and final C.

P11	No	%	P12	No	%
Voiced	226	52	Voiced	320	73
Voiceless	210	48	Voiceless	116	27

Table 10: *Parameter 13: Voice agreement.*

P13	No	%
Total	144	33
Partial	181	42
None	111	25

As can be observed, only one pattern defines the majority of verbal roots. A voiced consonant in the word-final position is found in 73% of items. The proportion of [+voice] and [-voice] segments in C1 is comparable. No prevalent pattern can be observed for the voice agreement parameter. Entirely voiceless verbs (15 items) are much less common than verbs that are uniformly voiced. This large distributional variability cannot be attributed solely to the larger number of voiced consonants in the segmental inventory of the language, suggesting a clear preference for the presence of at least one voiced segment within each verbal root.

3.4. Ranking of parameters

In order to establish a ranking of the parameters which determine the structure of Tashlhiyt verbal roots, we performed a *Principal Component Analysis* (PCA). The method is appropriate for the present analysis as it allows to reduce numerous variables (13 parameters) to 13 linearly uncorrelated principal components. Each component (Comp) explains a portion of the observations. The variance of the first component is maximized, i.e. it explains the largest portion of the data. Successive comp2-13 account for the data which is not explained by the preceding component(s). Here, Comp1-2 explain 52% of the data (cumulative proportion=0.5227859), and only they will enter into further computation.

Comp1-2 serve to weight the 13 parameters by means of PCA loadings. The loadings indicate the discriminatory power of each parameter. The loading values range from 0 to 1. That is, the higher the loading value, the greater the weight of a parameter. Since the loadings are relatively low here (average=0.18 in Comp1), in line with previous contributions [16, 17] we set the threshold ≥0.4 for data interpretation. Loadings with this minimal value are listed for Comp1 in Table 11. As a result, three parameters surface as relevant predictors of the word structure in Tashlhiyt.

Table 11: Ranking of parameters (Comp1).

Rank	Parameters	%
1	S/O contrast word-initially (P2)	47
2	Cluster length (P1)	22
3	Manner contrast word-initially (P3)	16

Table 11 lists parameters with the greatest statistical weight. P2, P1 and P3 are ordered according to their decreasing PCA loadings (P2=0.683, P1=-0.466, P3=0.395 in Comp1) which correspond with a decrease in rank. (Comp2 yields comparable results, with P1 and P2 having the highest PCA loadings). Loading values turned into percentages (%) indicate the degree to which a particular parameter explains the variability of the data.

Statistically-relevant parameters (P2, P1, P3) represent the manner of articulation features and word length. The distinction between sonorants and obstruents word-initially as well as three-member clusters show to be the most fundamental predictors of cluster structure. Place of articulation and voicing do not show to play a crucial role in verbal roots.

4. Discussion

The results of the qualitative and quantitative analyses offer new insights into the phonological structure of verbal roots in Tashlhiyt. The study demonstrates that different parameters play a different role in the distribution of segments in vowelless sequences. The manner of articulation of the first consonant as well as word length show to be the most relevant building blocks of the phonotactic grammar in the language. In line with [16, 17], the parameters listed in Table 11 can be viewed as phonotactic preferences. That is, Tashlhiyt verbal roots preferably start with an obstruent (in particular a fricative), and are composed of three segments.

To recapitulate, these observations, although preliminary, shed new light on the structural and distributional constraints that shape the segmental composition of Tashlhiyt consonant-only verbal roots. What seems to be a dysfunctional structure for most linguistic systems can in fact follow from a particular set of feature-based preferences. This paper contributes to the discussion on universal principles and language-specific preferences.

5. Conclusions

The goal of this preliminary study was to investigate the complexity of vowelless verbal roots in Tashlhiyt Berber. We have demonstrated that the phonological structure of words composed of two to five consonants is largely governed by several parameters pertaining to the manner of articulation and cluster length. The analysis opens new veins of study which do not rely solely on the unit of the syllable, and on the principle of sonority. As the results of this study are based on a small dataset, future research will include the comparison of vowelless roots with roots containing a full vowel, ensuring a more systematic analysis of the specific patterning of consonant consonants.

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