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Tashlhiyt's ban of complex syllable onsets: phonetic and perceptual evidence

Abstract: Tashlhiyt is famous for its particularly marked syllable structure. Unlike the majority of world languages, including some related Berber varieties, Tashlhiyt allows not only vowels but all consonants – including voiceless stops /t/, /k/ or /q/ – to be nuclei of a syllable (e.g., [tkmi] 'she smoked' is analyzed as bisyllabic where the sequence [tk] stands for a syllable of its own with /k/ as the nucleus). A fundamental aspect of this analysis concerns constraints on the syllable onset constituent: complex onsets are prohibited. A consequence of this is that prevocalic consonant clusters are systematically parsed as heterosyllabic, regardless of the sonority profile of the consonants and the position of the cluster within a word or a phrase. This study provides phonetic and metalinguistic data to test this phonological account on experimental grounds. The analysis of these data provides clear evidence that Tashlhiyt disallows complex syllable onsets.

Keywords: Tashlhiyt, syllable, complex onset, articulation, perception

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1 Introduction

The rather uncommon syllable structure of Tashlhiyt is well documented. Unlike the majority of world languages, Tashlhiyt is claimed to allow any segment, even voiceless stops, to be syllable peaks (Elmedlaoui 1985; Dell & Elmedlaoui 1985, 1988, 2002; Boukous 1987; Prince & Smolensky 1993/2004; Jebbour 1995; Clements 1997; Ridouane 2003, 2008; Ridouane & Fougeron 2011). In addition to the classic syllable types V, CV, VC and CVC, Tashlhiyt also has consonant-only syllables: C, CC and CCC, as shown in (1):[1]

(1a)	V	N_{uc}	**a.**man	a-man	‘water’
(1b)	CV	O_nN_{uc}	**ta**.ma	tama	‘near’
(1c)	VC	$N_{uc}C_o$	**az**.ru	a-zru	‘stone’
(1d)	CVC	$O_nN_{uc}C_o$	**tas**.ga	tasga	‘side’
(1e)	C	N_{uc}	**g**.li	gli	‘guide’
(1f)	CC	O_nN_{uc}	**tχ**.wa	t-χwa	‘it was empty’
(1g)	CC	$N_{uc}C_o$	**nk**.mi	n-kmi	‘we smoked’
(1h)	CCC	$O_nN_{uc}C_o$	i.**zrb**	i-zrb	‘he was in a hurry’

The main reason why any consonant may act as a syllable peak is that Tashlhiyt allows particularly long consonant sequences. These sequences can occur in all possible prosodic positions: word-initially (e.g., [brːʕziz] ‘hornet’), intervocalically (e.g., [asqːsi] ‘question’), and finally (e.g., [asgrs] ‘bag’). Tashlhiyt also has words, mainly verbs, composed of consonants only (e.g., [rgl] ‘close!’, [tkkststt] ‘you took it (f) off’), and an utterance may contain more than 20 consonants in a raw (e.g., [trzmtnt tqʃʃrtnt qqbl tʃʃtnt s zzrba] ‘she opened them, peeled them before and ate them in a hurry’); a typologically unique phenomenon to the best of our knowledge.

From a phonotactic point of view, the combination of consonants in a cluster is strictly constrained in terms of place of articulation while it is quite permissive in terms of manner of articulation and voicing specifications (see Boukous 1987 for a detailed presentation). For example, no monomorphemic word may contain two adjacent labial obstruents [*bf, *fb], two back obstruents [*kq, *qg, *χʁ, etc.], or two strident fricatives [*sʃ, *ʒz], while the four possible combinations of manner or voice for obstruents are attested (2).

(2) Manner			Voicing
stop-stop	/kdu/	‘to smell’	voiceless-voiced
stop-fricative	/bsi/	‘to melt’	voiced-voiceless
fricative-stop	/zdi/	‘to fasten’	voiced-voiced
fricative-fricative	/fsi/	‘to melt’	voiceless-voiceless

1 Gemination and prepausal annexation are not dealt with here. Syllabic vs. morphemic boundary is denoted with “.” vs. “-” in the third vs. fourth column, respectively. The first two columns show the structure of the bold type syllable in column three. N_{uc} = nucleus, O_n = onset, C_o = coda.

As also illustrated in (2), Tashlhiyt allows word-initial clusters that violate traditional principles of sonority well-formedness. Words may begin with a plateau or a falling sonority profile (e.g., [kti] 'to remember'; [rku] 'to be dirty'), in addition to more common sonority rising profile (e.g., [kru] 'to rent').

In conjunction with these phonotactic properties, Tashlhiyt syllabification is claimed to be sensitive to two basic constraints, a sonority-based constraint that hierarchizes the types of segments that may be syllable nuclei (more sonorous segments are favored over less sonorous ones) and margin constraints that regulate syllable boundaries (Dell & Elmedlaoui 2002; Prince & Smolensky 1993/2004). Among the margin constraints, the one prohibiting complex onsets is highly active and can never be violated.[2] A consequence of the "simple onset" account is that all prevocalic consonant clusters, regardless of cluster's consonants, cluster's sonority profile, and within-word or within-phrase cluster's position, are heterosyllabic. That is, XCCVX forms (where X is a word boundary or any string of consonants and vowels) are parsed as XC.CVX. For example, /gli/ in (1e) is parsed as [g.li]: the sequence /li/ makes a syllable, whose nucleus is /i/, and /g/ makes another syllable, with no onset[3] and whose nucleus is /g/. Sequences such as [gl] are not permissible syllable onsets in Tashlhiyt, although a stop followed by a liquid complies with the Sonority Sequencing Principle (SSP, compare to English monosyllabic <glee>). Likewise a three-consonant cluster as in (1f) is parsed heterosyllabically although it does not violate the SSP (compare to French monosyllabic <trois> 'three').

In this study we are interested in assessing whether the heterosyllabicity of Tashlhiyt consonant clusters is reflected at the phonetic and perceptual levels. Building on previous work, the phonetic analysis examines whether the simple onset analysis is instantiated in the temporal organization of the articulatory gestures. The perception study provides metalinguistic judgments about how native speakers/listeners syllabify and delineate consonant clusters.

2 Simple onset analysis: phonetic evidence

Ongoing research in Articulatory Phonology has provided important evidence for the claim that syllable organization can be inferred from the temporal patterns in

2 In Dell & Elmedlaoui's (1985) and (1988), complex onsets could surface as a later stage of the derivation. That is, obstruent nuclei occurring immediately after a pause were readjusted as part of a complex onset. However, in their 2002 book, based on orthometric syllabification, all complex onsets were disallowed.

3 Onsetless syllables are permissible only in utterance-initial position. Illustration items such as /gli/ are isolated utterances, which are both prepausal and postpausal at the same time.

speech production (e.g., Browman & Goldstein 1988; Krakow 1989, 1999; Sproat & Fujimura 1993; Byrd 1995, 1996; Honorof & Browman 1995; Goldstein et al. 2007; Fougeron & Ridouane 2008; Hermes et al. 2011, 2013; Shaw et al. 2009, 2011). As far as the onset constituent is concerned, the difference between simple onset languages and complex onset languages is reflected in the different timing patterns of the consonants within the clusters of these languages.

Specifically, in languages allowing complex onsets, all the consonants in the cluster adjust their timing relative to a following articulatory anchor. This adjustment is instantiated in that the interval between the "center" of the cluster (i.e., the cluster midpoint) is timed in a stable way relative to a following anchor in the word (e.g., vowel-nucleus, or consonant-coda gesture). In other words, the time interval between the center of the onset cluster and the anchor does not change across words with increasing numbers of initial consonants. This is known as the C-center effect, or center stability. This pattern, schematized in Figure 1, has been observed in American English (Browman & Goldstein 2000; Marin & Pouplier 2010), Georgian (Goldstein et al. 2007), Italian (Hermes et al. 2013), and Romanian (Marin 2011).

In languages disallowing complex onsets, the observed pattern is different. Here, the temporal alignment corresponds to a configuration whereby only the rightmost consonant of the cluster is timed in a stable way relative to a following anchor. That is, regardless of the number of consonants in the cluster, the right-

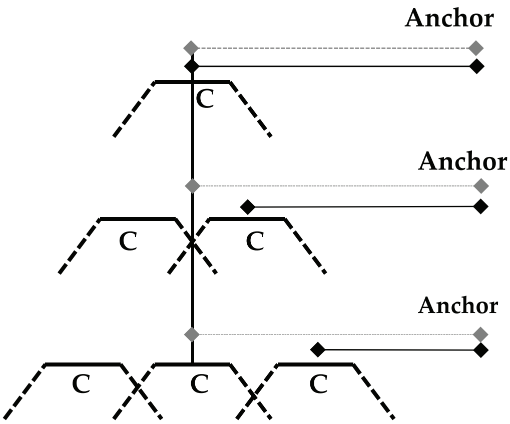

Fig. 1: Schematic representation of C-center stability illustrating the temporal organization associated with complex onsets. As consonants are added to the onset, the center to anchor interval remains stable whereas the interval between the rightmost consonant and the anchor decreases.

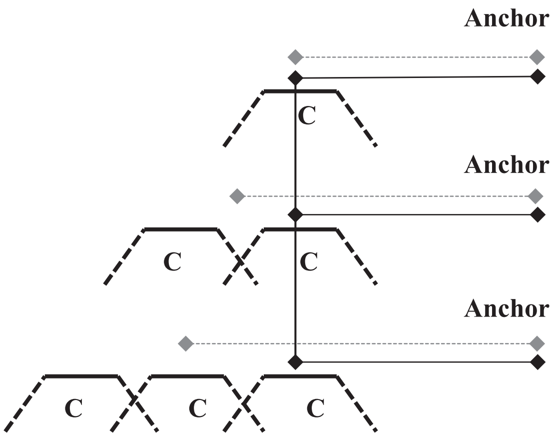

Fig. 2: Schematic representation of right-edge stability illustrating the temporal organization associated with simple onsets. As consonants are added syllable-initially, the rightmost consonant to anchor interval remains stable whereas the interval between the center of the cluster and the anchor increases.

most consonant will maintain a stable pattern relative to the anchor point. This pattern, schematized in Figure 2, is known as right-edge stability.

In a series of publications, Shaw et al. (2009, 2011) presented clear evidence for this pattern in Moroccan Arabic, suggesting that this language disallows complex syllable onsets. Prior to these studies on Moroccan Arabic, Goldstein et al. (2007) presented preliminary data on Tashlhiyt from one subject producing the triad /mun/ 'accompany', /s-mun/ 'caus-accompany', and /t-s-mun/ '3fs-caus-accompany'. They found that, contrary to the languages allowing complex onsets, the interval between the rightmost consonant of the cluster (here /m/) and the following anchor does not decrease but remains stable as the number of initial consonants increases. Building on this previous work, our study tests the simple onset hypothesis based on more extensive data. In addition to the rightmost C variable used in Goldstein et al.'s (2007) study, we also use the C-center variable and analyze relative standard deviation across repetitions (RSD: Shaw et al. 2009), which can be viewed as a stability index. Furthermore, we test whether the same gestural timing patterns are observed in items with vocalic versus consonantal nuclei.

2.1 Method

We recorded 3 native speakers of the Agadir variety of Tashlhiyt (aged 37 to 39 years) with a 2D EMA (Electro-Midsagittal Articulograph) at the IfL Phonetik, University of Cologne. Coils were placed on upper and lower lip, tongue tip, tongue blade and tongue body. For head correction two coils were placed on the upper gums and the bridge of the nose. To rotate the articulatory data in relation to the occlusal plane, a bite plate was used. The acoustic recordings were recorded at 400Hz, downsampled to 200Hz and smoothed with a 40Hz low-pass filter.

The speech material consisted of 12 target words organized into 4 triads, given in (3). All the triads were structured so that they differ only in the number of initial consonants. In order to compare items with different nucleus types, two triads have a vowel as nucleus: CVC, CCVC and CCCVC and two others have a sonorant consonant as nucleus (underlined C): CCC, C.CCC and CC.CCC. In the following, the rightmost C of a word-initial consonant sequence is taken as the last consonant before nucleus. The target items were embedded in a carrier sentence: *inna* ___ *bahra* ('He said ___ a lot') and randomized within a larger set of words comprising 42 additional items, which are not under scrutiny in the present study. A total of 252 tokens (12 target words × 3 speakers × 7 repetitions) are analyzed in this study.

(3)	Vocalic nucleus			Consonantal nucleus		
C	fik	–	kif	fnk	–	klf
CC	kfik	–	lkif	kfnk	–	lklf
CCC	tkfik	–	flkif	tkfnk	–	flklf

The acoustic and articulatory data were hand-labeled using the EMU Speech Database System. We first identified the time location of the target words and their segments in the acoustic domain. In order to analyze the gestural timing intervals, we labeled the onset, peak velocity, and target for each vocalic and consonantal gesture. Gestural onsets and targets were identified at zero-velocity points; peak velocity was identified at zero-acceleration points. The target of the coda consonant was chosen as the anchor. For each experimental word, the rightmost C to anchor interval was the time interval between the target of the rightmost C and the anchor. The C-center to anchor interval was the time lag between the mean location of the word-initial consonantal targets (i.e., the C-center location) and the anchor. We also computed RSDs across repetitions for both rightmost C and C-center to anchor intervals: lower RSD corresponds to better stability.

2.2 Results

If consonant clusters in Tashlhiyt do not form a complex onset they would not be expected to exhibit a C-center effect. Rather they should exhibit a pattern of stability between rightmost C and following anchor. For example, for the triad [fik kfik tkfik], the lag between the target of the rightmost C /f/ and the target of the coda consonant /k/ should remain stable regardless of the number of initial consonants, whereas the C-center interval should increase. This is exactly the pattern observed in our data, as summarized in Table 1, in which the time lags (and standard deviations) between rightmost C or C-center and anchor are reported. As can be seen, for example, for the triad [fik kfik tkfik] produced by S1, the time lag between rightmost C /f/ and anchor /k/ is virtually constant, whereas the time lag between C-center and anchor /k/ systematically increases from [fik] to [tkfik].

We first conducted a series of one-way ANOVAs, for each speaker separately, on either the rightmost C or C-center to anchor time lag as the dependent variable, with NUMBER of initial consonants (one, two, or three) as the independent variable, and REPETITION number as the random variable. A Bonferroni correction was applied for multiple comparisons ($\alpha' = 0.0043$). Overall, NUMBER had no effect on the rightmost C variable ($p > .01$), while it significantly affected the C-center variable ($p < .005$). We then conducted ANOVAs on the same dependent variables, with the additional factor NUCLEUS type (vowel vs. consonant) and SUBJECT as a repeated measure. Tukey post-hoc tests were used. This analysis reveals again that NUMBER strongly affects the C-center variable (one < two < three), $F(2,36) = 42.4$, $p < 0.001$ (effect sizes: $d = 0.75$ for one < two, and $d = 0.76$ for

Table 1: Mean values for gestural timing intervals in ms (SD) for rightmost C and C-center to anchor, for vocalic and consonantal nuclei, and for each speaker

	Rightmost C to anchor			**C-center to anchor**		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**
Vocalic nucleus						
fik	124 (9)	138 (11)	140 (8)	124 (9)	138 (11)	140 (8)
kfik	123 (9)	126 (8)	131 (8)	139 (8)	153 (8)	171 (11)
tkfik	123 (9)	117 (10)	128 (7)	198 (3)	196 (15)	226 (9)
kif	155 (16)	148 (18)	156 (20)	155 (16)	148 (18)	156 (20)
lkif	175 (20)	159 (9)	159 (9)	212 (20)	188 (10)	188 (10)
flkif	169 (7)	134 (20)	164 (25)	242 (7)	220 (15)	250 (23)
Consonantal nucleus						
fnk	126 (7)	136 (8)	164 (22)	126 (7)	136 (8)	162 (22)
kfnk	119 (4)	129 (8)	132 (12)	145 (3)	156 (7)	172 (14)
tkfnk	123 (4)	1297 (9)	140 (8)	198 (3)	212 (10)	240 (13)
klf	138 (13)	159 (9)	174 (29)	138 (13)	159 (9)	174 (29)
lklf	163 (12)	149 (16)	155 (18)	198 (11)	185 (17)	182 (19)
flkf	154 (12)	138 (15)	171 (17)	230 (11)	225 (18)	253 (15)

two < three), but does not affect the rightmost C variable, $F(2,36) < 1$. NUCLEUS had no significant effect.

The RSDs, also known as “coefficient of variance”, were computed as follows: 100 × (standard deviation across repetitions)/mean. Intervals with lower RSD show greater stability. The RSD values are about two times larger for the C-center (mean 20%) than the rightmost C (mean 10%) intervals, indicating a clear stability advantage for the latter over the former (see Hermes et al. 2011 for a more detailed presentation of these results).

2.3 Summary of the phonetic experiment

We have presented articulatory data on gestural coordination showing how Tashlhiyt word-initial clusters are timed relative to a fixed anchor point and how this time alignment is related to the syllabification proposed for these clusters. For all the triads examined, regardless of vocalic vs. consonantal nuclei, a clear pattern emerges: the C-center to anchor interval increases with the number of word-initial consonants, whereas the rightmost C to anchor interval is stable. Word-initial clusters in Tashlhiyt are thus timed differently from the initial clusters that form a complex onset in other languages (e.g., American English, Georgian, Italian, Romanian) and display the same pattern as Moroccan Arabic initial clusters. This right-edge stability effect provides important evidence in favor of the phonological analysis that disallows complex onsets in Tashlhiyt. We assume that this timing information is one facet of the linguistic knowledge shared by the native speakers of Tashlhiyt: they may rely to a great extent on such knowledge to syllabify items. We test this possibility in the following section, which reports syllabification metalinguistic data from native speakers of Tashlhiyt.

3 Simple onset analysis: psycholinguistic evidence

We conducted a part-repetition task experiment to test how native speakers of Tashlhiyt syllabify prevocalic two-consonant clusters. As mentioned earlier, one phonological analysis (Dell & Elmedlaoui 2002) claims that such sequences are always heterosyllabic, regardless of the cluster consonants and its sonority profile.

3.1 Participants and stimuli

Twenty native speakers of Tashlhiyt (mean age 24) participated in the experiment. They all were students at Ibno Zohr University, Agadir, had been raised in the Tashlhiyt-speaking region of Souss (South of Morocco), and reported they continued to use Tashlhiyt on a regular basis. All the participants also had linguistic competence in Moroccan Arabic, Standard Arabic and French. They were paid €10 for their participation to the experiment, which lasted approximately one hour.

A set of 56 (C)VCCV(C) items was constructed.[4] They varied in terms of morphological structure and sonority profile of the CC sequence. Twenty-nine items were monomorphemic (e.g., [amlal] 'sand') and 27 were heteromorphemic, out of which 19 were prefixed (e.g., /i-sli/ '3ms-touch') and 8 were suffixed (e.g., /aws-as/ 'help-dat3s'). We controlled morphological structure in order to assess whether native speakers' segmentation of Tashlhiyt utterances corresponds to morpheme boundaries:[5] for instance, /aws-as/ segmented in the two parts [aws] and [as]. The sonority profile of the CC sequence defined three groups of items: rising (e.g., /adrar/ 'mountain'), falling (e.g., /amzil/ 'blacksmith'), and plateau profile (e.g., /agbur/ 'squirrel'). Principles governing the syllabification of consonant sequences such as the Onset Maximization Principle (Clements & Keyser 1983; Blevins 1995) and the Sonority Sequencing Principle and its coda-to-onset qualification (Clements 1990), have been claimed to play a fundamental role in determining possible onsets. These two principles suggest a cross-linguistic preference for V.CCV over VC.CV syllabifications as long as CC has a rising sonority profile. This preference seems universal in the case of obstruent plus liquid (OL) clusters. If the claim that Tashlhiyt bans complex onsets is correct, we expect VCCV items to be parsed as VC.CV, regardless of the sonority profile of the CC cluster, and whether or not it is an OL cluster.

The stimuli were recorded by a 32-year-old female native speaker, who was naive to the purpose of the study. The 56 stimuli were randomized into 12 different orders of presentation (6 "basic" orders and their corresponding mirror orders), yielding 12 lists of the same 56 stimuli. Each participant was presented with the stimuli of one list with the instruction to repeat either the first part of each stimulus (one half of the participants) or the second part (the other half of the participants). The experiment was described to participants (in Tashlhiyt) as a lan-

4 A larger set of items was used in order to introduce some variety in the structure of the items. These include (C)VCV(C) and VC_iC_iV items (where C_iC_i = geminate), which will be analyzed in another study.

5 In our data, morphological boundaries never coincide with syllable boundaries.

guage game in which participants had to listen to words and repeat 'the first part' (*agzzum amzwaru*) or 'the second part' (*agzzum wiss sin*) of each item. The rules of the "game" were explained using examples in which we avoided morphemes as possible "parts" since we manipulated morphemic composition as a possible factor influencing the participants' judgments. Instead, the experimenter (RR) used examples consisting of two identical parts. For example, for the repetition of either the first or the second part, participants were told "iʁ nniʁ *gawgaw* rad tinit *gaw*" ('If I say *gawgaw* (a kind of fish), you will say *gaw*'). Other examples were [baba] 'my father', [baʁbaʁ] 'a kind of fish', etc. Participants completed a short training session before starting the experiment. Stimuli were presented using a laptop computer over headphones at a comfortable listening level. On each trial, the participant's response was immediately transcribed by the experimenter before the next trial was started. Participants' vocal responses were at the same time recorded on a Marantz PMD 660 solid state recorder for further verification of the transcriptions entered by the experimenter. A simple AppleScript script controlled stimulus presentation and transcription input.

3.2 Results

Percentage responses for the test items are given in Tables 2 and 3. These items were coded separately for the first part and the second part conditions. For the first part condition, there were three possible types of response: (C)V, VC, and VCC (e.g., [usman]: u, us, usm). For the second part condition, there were also three possible types of response: VC, CVC and CCVC (e.g., [usman]: an, man, sman).

The results shown in Table 2 reveal that morphological structure did not affect item segmentation. The distribution of responses for Part 1 and Part 2 was

Table 2: Distribution of the responses to (C)VCCV(C) items according to morphological structure (HM: heteromorphemic, MM: monomorphemic) and response type[6]

	Part 1 (%)				**Part 2 (%)**			
	(C)V	**(C)VC**	**(C)VCC**	**Other**	**VC**	**CVC**	**CCVC**	**Other**
HM	1.9	**95.6**	2.6	0.0	4.8	**93.0**	1.1	0.7
Prefixed	1.6	96.3	2.1	0.0	3.2	93.7	1.6	1.1
Suffixed	2.5	93.8	3.8	0.0	8.8	91.3	0.0	0.0
MM	1.0	**97.9**	0.3	0.7	1.7	**94.8**	3.4	0.0

6 The "other" category corresponds to skipped items or cases where a participant repeated the incorrect part (e.g., *us* for [usman] in the Part 2 condition).

Table 3: Distribution of the responses to (C)VCCV(C) items according to the sonority profile of CC

	Part 1 (%)				Part 2 (%)			
	(C)V	(C)VC	(C)VCC	Other	VC	CVC	CCVC	Other
Rising	1.6	97.6	0.8	0.0	2.8	95.5	2.0	0.7
Plateau	1.6	95.8	2.1	0.5	4.2	94.7	1.1	0.0
Falling	0.8	96.7	1.7	0.8	2.5	91.7	5	0.8

virtually identical for heteromorphemic and monomorphemic items. In both cases, the items were almost always parsed with (C)VC as the first part (95.6% for heteromorphemic items and 97.9% for monomorphemic items) and CVC as the second part (93% for heteromorphemic items and 95% for monomorphemic items). Only 1.5% of Part 2 responses show a CCVC parsing with a complex onset.

Table 3 shows the distribution of responses to (C)VCCV(C) items according to the sonority profile of the CC sequence. Again, the large majority of responses were (C)VC for the first part, and CVC for the second part. That is native listeners parsed the CC sequences as heterosyllabic, regardless of sonority profile. This pattern held for all the CC clusters, including OL clusters (5 out of 56 clusters). In this respect, Tashlhiyt, unlike many languages of the world, uniformly prefers to split multiple consonants across different syllables rather than grouping them, even into cross-linguistically widespread OL clusters. Tashlhiyt thus clearly disprefers complex onsets.

3.3 Summary of the psycholinguistic experiment and perspectives

The part-repetition task experiment provides clear evidence that Tashlhiyt native speakers uniformly analyze (intervocalic) CC clusters as heterosyllabic. For Part 2 responses, participants overwhelmingly preferred CV(C) over CCV(C) responses (94 >> 3%). The sonority profile of the CC sequence did not significantly influence listeners' judgments. Our pattern of results is thus in conformity with the phonological analysis that systematically parses such clusters as heterosyllabic. Strikingly, this pattern held for OL clusters as well as for other clusters, although OL clusters are tautosyllabic in most languages. Furthermore, Tashlhiyt's avoidance of tautosyllabic is not limited to intervocalic clusters. It is also observed in word-initial clusters (Ridouane & Hallé, in preparation). We have conducted another perception experiment in which participants (the same 20 participants as for the part-repetition task) directly reported the different "parts" of the words they were presented with. The experiment was described as a game about word musicality in which participants had to listen to words and repeat each "part" of the word separately while tapping on their hands. Eighteen of the 101 test words had a CCV(C) or CCCV structure. For these items with a word-initial cluster, more than 94% of the responses corresponded to a bisyllabic parsing. Consider for example two such items: [gli] 'guide' and [tχwa] 'it is empty' presented in (1e) and (1f) above. These forms sound like English *glee* and French *trois*, respectively. But whereas they are monosyllabic in English and French, Tashlhiyt native speakers overwhelmingly judged them as having two parts: [g] and [li] for the former, and [tχ] and [wa] for the latter.

4 General conclusion

This study provided articulatory and perception data to test the claim that Tashlhiyt disallows complex syllable onsets. Data on gestural coordination showed that the temporal alignment of Tashlhiyt word-initial clusters corresponds to a configuration whereby only the rightmost consonant of the cluster is timed in a stable way relative to a following anchor. This pattern is characteristic of simple syllable onset languages and differs from what has been observed in languages allowing complex onsets, such as English, Italian, Georgian and Romanian. In addition to the evidence from the articulatory study, further evidence that Tashlhiyt disallows syllables with complex onsets comes from a perception study based on a part-repetition task experiment. It showed that Tashlhiyt native speakers uniformly analyze intervocalic CC clusters as heterosyllabic, regardless of the sonority profile of the clusters. This pattern holds even for obstruent-liquid clusters, claimed to be universally parsed as tautosyllabic. Ongoing research into native speakers' judgments about syllable count shows that Tashlhiyt's avoidance of complex onsets is not limited to intervocalic clusters; it is also observed in word-initial clusters.

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References

Blevins, Juliette (1995): The syllable in phonological theory, in: Goldsmith, John (ed.), *The handbook of phonological theory*. Blackwell: Oxford, 206–244.

Boukous, Mohamed (1987): Phonotactique et domaine prosodique en berbère (parler tachelhit d'Agadir, Maroc). PhD dissertation, Université Paris 8.

Browman, Catherine & Goldstein, Louis (1988): Some notes on syllable structure in articulatory phonology, in: *Phonetica* 45, 140–155.

Browman, Catherine & Goldstein, Louis (2000): Competing constraints on intergestural coordination and self organization of phonological structure, in: *Les Cahiers de l'ICP* 5, 25–34.

Byrd, Dani (1995): C-Centers Revisited, in: *Phonetica* 52, 285–307.

Byrd, Dani (1996): Influences on articulatory timing in consonant sequences, in: *Journal of Phonetics* 24, 209–244.

Cassidy, Steve & Harrington, Jonathan (2001): Multi-level annotation in the Emu speech database management system, in: *Speech Communication* 33, 61–77.

Clements, Georges N. (1990): The role of the sonority cycle in core syllabification, in: John Kingston & Mary Beckman (eds.), *Papers in laboratory phonology* I. Cambridge: Cambridge University Press, 283–333.

Clements, Georges N. (1997): Berber syllabification: derivations or constraints?. in: Roca, Iggy (ed.), *Derivations and constraints in phonology*. Oxford: Clarendon, 289–330.

Clements, Georges N. & Keyser, Jay (1983): *CV phonology: a generative theory of the syllable*. Cambridge: MIT Press.

Dell, François & Elmedlaoui, Mohamed (1985): Syllabic consonants and syllabification in Imdlawn Tashlhiyt Berber, in: *Journal of African Languages and Linguistics* 7, 105–130.

Dell, François & Elmedlaoui, Mohamed (1988): Syllabic consonants in Berber: some new evidence, in: *Journal of African Languages and Linguistics* 10, 1–17.

Dell, François & Elmedlaoui, Mohamed (2002): *Syllables in Tashlhiyt Berber and in Moroccan Arabic*. Dordrecht: Kluwer.

Elmedlaoui, Mohamed (1985). Le parler berbère chleuh d'Imdlawn (Maroc): segments et syllabation. PhD dissertation, Université Paris 8.

Fougeron, Cécile & Ridouane, Rachid (2008): On the phonetic implementation of syllabic consonants and vowel-less syllables in Tashlhiyt, in: *Estudios de Fonética Experimental* 18, 139–175.

Goldstein, Louis; Chitoran, Ioana & Selkirk, Elisabeth (2007): Syllable structure as coupled oscillator modes: evidence from Georgian vs. Tashlhiyt Berber, in: *Proceedings of the 16th ICPhS, Saarbrücken, Germany*, 241–244.

Hermes, Anne; Ridouane, Rachid; Mücke, Doris & Grice, Martine (2011): Kinematics of syllable structure in Tashlhiyt Berber: the case of vocalic and consonantal nuclei, in: *Proceedings of the 9th international seminar on speech production*, Montréal, Canada, 401–408.

Hermes, Anne; Mücke, Doris & Grice, Martine (2013): Gestural coordination of Italian word-initial clusters: the case of 'impure s', in: *Phonology* 30(1), 1–25.

Honorof, Douglas & Browman, Catherine (1995): The center or edge: how are consonant clusters organized with respect to the vowel?, in: *Proceedings of the XIIIth international congress of phonetic sciences*, vol. 3, 552–555.

Jebbour, Abdelkarim (1995): Mores et poids prosodique en berbère, in: *Langues Orientales Anciennes: Philologie et Linguistique* 5/6, 167–192.

Krakow, Rena (1989): *Articulatory organization of syllables: a kinematic analysis of labial and velar gestures*. Ann Arbor, Mich.: University Microfilms International.
Krakow, Rena (1999): Physiological organization of syllables: a review, in: *Journal of Phonetics* 27, 23–54.
Marin, Stefania & Pouplier, Marianne (2010): Temporal organization of complex onsets and codas in American English: testing the predictions of a gestural coupling model, in: *Motor Control* 14(3), 380–407.
Marin, Stefania (2013): The temporal organization of complex onsets and codas in Romanian: a gestural approach, in: *Journal of Phonetics* 41 (3/4), 211–227.
Prince, Alan & Smolensky, Paul (1993/2004): *Optimality Theory: constraint interaction in generative grammar*. Malden: Blackwell Publishing.
Ridouane, Rachid (2003): Suites de consonnes en berbère: phonétique et phonologie. PhD dissertation, Université Paris 3.
Ridouane, Rachid (2008): Syllables without vowels: phonetic and phonological evidence from Tashlhiyt Berber, in: *Phonology* 25(2), 321–359.
Ridouane, Rachid & Fougeron, Cécile (2011): Schwa elements in Tashlhiyt word-initial clusters, in: *Journal of Laboratory Phonology* 2, 1–26.
Ridouane, Rachid & Halle, Pierre (in preparation): Syllabification in Tashlhiyt: a perception experiment.
Shaw, Jason; Gafos, Adamantios I.; Hoole Philip & Zeroual, Chakir (2009): Syllabification in Moroccan Arabic: evidence from patterns of temporal stability in articulation, in: *Phonology* 26, 187–215.
Shaw, Jason; Gafos, Adamantios I.; Hoole Philip & Zeroual, Chakir (2011): Dynamic invariance in the phonetic expression of syllable structure: a case study of Moroccan Arabic consonant clusters, in: *Phonology* 28, 455–490.
Sproat, Richard & Fujimura, Osamu (1993): Allophonic variation in English /l/ and its implications for phonetic implementation, in: *Journal of Phonetics* 21, 291–311.