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Syllable structure and complex onsets in Modern Hebrew

Daniel Asherov
MIT
asherov@mit.edu

Outi Bat-El
Tel-Aviv University
obatel@tauex.tau.ac.il

Abstract

Modern Hebrew allows for a diverse variety of syllable structures, allowing syllables with codas, onsetless syllables, and complex syllable margins. Syllables with a complex onset are found in word initial position, mostly in nouns, and syllables with a complex coda are less common. In this paper, we provide the distribution of syllable types in Modern Hebrew, noting differences between verbs and nouns, native words and loanwords, as well as differences among positions within the word. Special attention is given to word initial complex onsets, with details regarding the restrictions governing consonant combinations.

Keywords

syllable – consonant clusters – complex onset – phonotactics – the Sonority Sequencing Principle (SSP) – the Obligatory Contour Principle (OCP)

1 Introduction

The syllable is assumed to be a basic phonological unit that organizes the segments on the basis of their sonority (Whitney 1865/1874, Sievers 1885/1901, Jespersen 1904, de Saussure 1915/1972). The nucleus/head of the syllable is usually a vowel, though some languages (e.g. Berber, English) also allow a consonant to

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occupy this position, i.e. a syllabic consonant. We use the terms onset and coda to refer to the consonant(s) preceding and following the head of the syllable, respectively.

This paper provides an overview of the properties of Modern Hebrew syllables. In § 2, we discuss the possible syllable structures, as well as their relative frequency and distribution with respect to word edges. We note systematic differences between nouns and verbs, and between native words and loanwords. We then dive into the properties of complex syllable margins in § 3, considering the phonological constraints that restrict the attested consonant combinations, as well as the language-specific gaps. We conclude in § 4.

2 The syllable

The most common syllables in native Hebrew words are CV and CVC, i.e. syllables with a simple onset, with or without a coda. However, Hebrew also allows onsetless syllables and syllables with complex margins. The frequency of the syllable types in Hebrew nouns is given in (1) below, with reference to the position of the syllable within the word. The counting, facilitated by Gafni's (2018) CPA, is based on Bolozky and Becker's (2006) Living Lexicon of Hebrew Nouns (LLHN), a lexicon of 12,043 nouns (native and non-native) drawn the Even-Shoshan dictionary (2003). Syllables in monosyllabic words (5%; n=587) were counted as word initial syllables.

(1) Distribution of syllables in noun stems

	Initial		**Medial**		**Final**		**Total**	
CV	5531	48.3%	4801	73.1%	3336	29.7%	13668	46.7%
CVC	3399	29.7%	1170	17.8%	7097	63.1%	11666	39.9%
V	872	7.6%	437	6.7%	144	1.3%	1453	5.0%
VC	555	4.8%	55	0.8%	421	3.7%	1031	3.5%
CCV	861	7.5%	37	0.6%	38	0.3%	936	3.2%
CVCC	63	0.6%	62	0.9%	188	1.7%	313	1.1%
CCVC	137	1.2%	9	0.1%	10	0.1%	156	0.5%
VCC	28	0.2%	0	0%	9	0.1%	37	0.1%
Total	11446	100%	6571	100%	11243	100%	29260	100%

The above table shows that most of the syllables (86.6%) in Hebrew nouns are either CV or CVC while the other syllable types are marginal in their distribution. The overall percentage of CV syllables is higher than of CVC (46.7% vs. 39.9%, respectively), though in word final position, CVC syllables are more common than CV syllables.[1]

Examples with the various syllable structures are given in (2). Note that the nucleus in Hebrew is always a vowel, i.e. syllabic consonants are prohibited. In addition, there is no evidence for a two-place nucleus, since Hebrew does not have a phonemic contrast in vowel length; thus, vowel-glide sequences are analyzed with a glide occupying a coda position (e.g. *daj* 'enough'), and glide-vowel sequences are analyzed with a glide in being part of a complex or simple onset (e.g. *djo* 'ink', *jad* 'hand').

(2) Hebrew syllable structures in native words

a. Most common syllables

		Word initial		**Word medial**		**Word final**	
i.	CV	χ**a**.lóm	'dream'	ma.**ta**.ná	'gift'	mal.**ká**	'queen'
		si.ká	'pin'	ʁa.**ké**.vet	'train'	ma.**vó**	'introduction'
ii.	CVC	**maf**.té.aχ	'key'	hit.**kaʁ**.bél	'snuggled'	miv.**dák**	'test'
		taf.kíd	'role'	suf.**gan**.já	'doughnut'	maχ.**sóm**	'barrier'

b. Syllables with complex margins

		Word initial		**Word medial**	**Word final**	
iii.	CCV	**kv**i.sá	'laundry'			
		tku.fá	'period'			
iv.	CCVC	**ʦʃ**a**ʁ**.dé.a	'frog'			
		ktav	'handwriting'			
v.	CVCC				ja.**ʃávt**	'you.FM sat'
					ta.**ʁámt**	'you.FM donated'

1 The preference of CVC syllables in word final position (found in native words) is historically motivated by the requirement of stems to end in a consonant; this requirement holds for earlier stages of Hebrew (as well as Arabic; McCarthy 2005), where vowel final stems were only derived due to the deletion of a word final glottal consonant or the vocalization of a glide.

c. Onsetless syllables

		Word initial		Word medial		Word final	
vi.	V	**a**.ní	'poor'	ta.**a**.gíd	'corporation'	pe.**á**	'wig'
		o.géʁ	'hamster'	se.**u**.dá	'fest'	ʁo.**é**	'see.MS'
vii.	VC	**aχ**.ján	'nephew'	ne.**el**.mú	'they disappeared'	be.**éʁ**	'well'
		of.ná	'fashion'	ni.**áʁ**.ti	'I shaked'	ʁo.**ím**	'see.MS.PL'
viii.	VCC					ʧa.**ákt**	'you.FM screamed'
						ʃa.**ált**	'you.FM asked'

Most consonants are free to appear in a singleton onset and coda position (see § 3 for complex onsets). We thus find, for example, *l* and *k* in onset and coda position (e.g. *lak* 'nail polish', *kal* 'easy'), as well as *g* and *t* (e.g. *gat* 'wine press', *tag* 'tag'), and *s* and *m* (e.g. *sam* 'put', *mas* 'tax'). The only exceptions are the glottal stop (*ʔ*) and glottal fricative (*h*), which do not appear in coda position.[2] While the glottal fricative rarely surfaces in natural speech, the glottal stop appears variably in syllables that are otherwise onsetless in phrase initial position (e.g. *(ʔ)aχʃáv* 'now'), and intervocalically under emphasis (e.g. *ʃavú(ʔ)a* 'week' and *tapú(ʔ)aχ* 'apple').[3] The phonemic status of glottals in Modern Hebrew is controversial; it is quite possible that for some speakers, these consonants, or at least the glottal fricative, appear in the underlying representation; for other speakers, they probably do not (Bolozky 1978a, 2003, Matras & Schiff 2005, Faust 2005, this volume, Enguehard & Faust 2018, Gafter 2014, this volume, Laks et al. 2016, Bassel & Berrebi 2016).

The frequency of syllable types in Hebrew (3) converges with universal typology (Clements and Keyser 1983, Blevins 1995), such that the more marked a structure is, the less frequent it is.

2 Glottal stops may appear in phrase final coda position in limited emphasized forms, such as *loʔ* '(emphatic) no'.

3 Onsetless syllables (2c) may arise due to the deletion of the historical glottal fricative (e.g. *ma.hér* → *ma.ér* 'fast'), a glottal stop (e.g. *pe.ʔá* → *pe.á* 'wig'), or voiced pharyngeal fricative (e.g. *ʃa.ʕá* → *ʃa.á* 'hour'). In addition, a glide followed by the high front vowel is often deleted in casual speech (*χajím* → *χaím* 'life').

(3) Markedness and frequency converge

	Unmarked			Marked	
a.	With onset	91.4%	>	Without onset	8.6%
b.	Without coda	54.9%	>	With coda	45.1%
c.	Simple onset	87.7%	>	Complex onset	3.7%
d.	Simple coda	43.9%	>	Complex coda	1.2%

The above generalizations assume the universal syllabification CV.CV and the language-specific syllabification CVC.CVC (other languages may syllabify CV.CCVC), though as we note at the end of § 3, there might be a certain degree of variation with respect to the syllabification of a medial consonant sequence.

Nouns and verbs differ slightly with respect to the type of syllables they allow (Schwarzwald 2002), with verbs being more restrictive than nouns. This is true of other cases of category-specific phonology in Hebrew, related to stress patterns (Bat-El 2005, Bat-El et al. this volume) and vowel-Ø alternation (Bat-El 2008). Unlike nouns, which allow complex onsets (see § 3), syllables in native verbs are restricted to a simple onset (e.g. *katáv* 'he wrote') or no onset (e.g. *amáʁ* 'he said'), with the exception of imperatives (e.g. ***kt**ov* 'write!'). As discussed in the following section, complex onsets are found only in denominative verbs, imperatives, and nouns (both native and borrowed).

3 Complex syllable margins

Syllables with complex margins are limited in native words to biconsonantal clusters, and appear only at the edges of the word—complex onsets in word initial position ($_{\omega}$[CCV …) and complex codas in word final position (… VCC]$_{\omega}$). Complex onsets appear in noun stems (e.g. ***kv**if* 'road') and suffixed nouns where the vowel in the first syllable is deleted (e.g. /gamal-im/ → ***gm**alím* 'camels'). Complex codas are rare in native Hebrew words, appearing only in past tense verbs with the 2nd person feminine suffix *-t* (e.g. *ʃaváʁ**t*** 'you.FM broke', *katáv**t*** 'you.FM wrote', *maχák**t*** 'you.FM erased').

Loanwords have expanded the distribution of complex syllable margins (Laufer 1990, Schwarzwald 1998, 2002, 2005, 2013, Cohen 2009, this volume), as they are now not limited to the edges of the word nor to two consonants (e.g. *kón.te**kst*** 'context', *ab.**stʁ**ák.ti* 'abstract'). The consonant cluster from the source word is usually preserved, as long as it obeys the Sonority Sequencing

Principle (see 4b below), such that there is no sonority rise from the nucleus to the syllable edge (recall from §1 that syllabic consonants are prohibited in Hebrew). Otherwise, a vowel is inserted to rescue the impermissible cluster (e.g. *d͡ʒén.tel.men* 'gentleman', *maʁksízem* 'Marxism').

Complex onsets are allowed in nouns, but not in verbs, with the exception of two cases. One is imperatives (either truncated or normative; Boloaky 1979, Bat-El 2002), in which C_1 and C_2 of the verb stem may form a word initial cluster (e.g. ***ʃmoʁ*** 'guard!'; cf. ***ʃamaʁ*** 'he guarded', ji***ʃmoʁ*** 'he will guard'). The other is denominative verbs, derived from multi-consonantal bases, usually loanwords (e.g. ***tʁansfér*** 'transfer (noun)' → ***tʁinsfér*** 'he transferred'), where the consonant sequences are preserved in the derived form (Bolozky 1978b, Bat-El 1994, Ussishkin 1999).

Complex codas, as noted above, are rare in Hebrew, appearing in past tense verbs with the addition of the 2nd person feminine singular suffix *-t*, and in loanwords (Cohen 2009, this volume).[4] Most complex codas end in an obstruent (e.g. ***ʁevérs*** 'reverse driving', ***aʁgumént*** 'argument', and in the absence of a final obstruent in a foreign cluster, the form is adapted with an inserted vowel (*pópkoʁen* 'popcorn'). There are, however, a few recent exceptions (e.g. ***palm*** 'handheld PC').

Unlike complex syllable margins at the edges of the word, those in the middle of the word are in some cases ambiguous. There are no phonological phenomena supporting a particular type of syllabification in Hebrew, and it is sometimes unclear where the syllable boundary resides (Albert 2014, this volume). In fact, there seems to be some degree of inter-speaker variation in syllabification of such sequences (Haim & Handelsman 2018). Thus, the medial cluster in *maklot* 'sticks' is syllabified as *mak.lót* (i.e. coda-onset) by some speakers, and as *ma.klót* (i.e. complex onset) by others.

In the rest of this section, we focus on the restrictions on initial complex onsets.

3.1 *Restrictions on complex onsets*

We start the discussion with two well-known constraints on syllable structure—the Sonority Sequencing Principle and the Obligatory Contour Principle. In the subsequent sections we attend to more specific constraints with reference to all attested and unattested clusters.

4 Complex codas exist in a few native words (Laufer 1990) borrowed as early as Biblical Hebrew (e.g. ***neʁd*** 'nard') and Mishnaic Hebrew (e.g. ***neft*** 'petroleum'), as well as in the native word ***ʁeff*** 'the letter ר', assuming that diphthongs are analyzed as VC sequences (§2). In the latter case, some speakers simplify the diphthong, thus producing ***ʁef*** (see Gafter this volume).

3.1.1 The Sonority Sequencing Principle

The Sonority Sequencing Principle (Steriade 1982, Selkirk 1984, Clements 1990, Blevins 1995, Parker 2002) restricts the distribution of complex margins cross-linguistically. It assumes that segments are placed on a sonority scale (4a), usually characterized in terms of perceived loudness, where stops are least sonorous, and vowels are most sonorous (Foley 1972). There are two versions of the Sonority Sequencing Principle: a restrictive version, which requires a sonority rise from the syllable edge to the nucleus (Selkirk 1984, Clements 1990), and a more permissive one, which also allows a plateau (Blevins 1995). As Hebrew allows a plateau (see §3.2), the permissive version (4b) is the one relevant here.

(4) a. The sonority scale: vowels > glides > liquids > nasals > fricatives > stops
b. The Sonority Sequencing Principle (SSP): Sonority must not rise from the syllable peak to the margin.

Onset combinations such as stop-stop, stop-fricative and fricative-fricative are all attested in Hebrew, as predicted by the SSP as defined in (4b). However, Hebrew also permits two types of complex onsets consisting of fricative-stop: sibilant-stop clusters (e.g. *ʃgiá* 'error', *spoʁt* 'spoʁt') and non-sibilant fricative-stop cluster, where the latter ones are found mostly in truncated imperatives (e.g. *ftaχ* 'open!', *χtov* 'write!'). The potential violation of the SSP by sibilant-stop clusters is attested cross-linguistically (Steriade 1982), and to rescue the violation, the sibilant in such clusters is often analyzed as part of an appendix rather than a complex onset (Plénat 1987 among many others; see review in Vaux and Wolfe 2009). However, extending the appendix to every cluster that violates the SSP is too powerful. It is possible that Hebrew phonology does not contrast between stops and fricatives on the sonority scale, and the reason such onsets are rare has to do with the history of the language, where fricatives where allophones of stops in postvocalic position, thus did not appear word initially (see Albert this volume). Another option is that such fricative-stop onsets indeed violate the SSP, and this is why such onsets are rare, but as it is a violable constraint, there must be a constraint that forces its violation.

Sonorants generally do not occupy the first position (C_1) in complex onsets in Hebrew (Rosen 1957, Schwarzwald 2002, 2005, 2013, Bolozky 2006). This constraint, dubbed *C_1SON and stated in (5), excludes sequences such as *nl* and *nʁ*, which satisfy the SSP but not attested in Hebrew. There are a few exceptions to this generalization (§3.4), though they are limited in form and in number, and always adhere to the SSP.

(5) *C_1SON C_1 of a complex onset is not occupied by a sonorant

The table below summarizes the types of complex onsets found in Modern Hebrew and their sonority profile, where the attested/potential (A/P) ratios are drawn from the matrices provided in the ensuing sections (with cross-reference in parentheses). Note that although Hebrew allows a relatively large variety of complex onsets, the A/P ratio of those exhibiting the least marked sonority profile, i.e. sonority rise, have the highest ratio.

(6) Attested/potential (A/P) ratio of complex onsets

Cluster type (cross-reference)	**A/P**	**Ratio**	**Sonority profile**
Stop-Sonorant (13)	31/42	74%	
Stop-Fricative (10)	33/42	79%	Sonority rise
Fricative-Sonorant (14)	23/36	64%	
Stop-Stop (9)	19/49	39%	Sonority plateau
Fricative-Fricative (12)	11/36	31%	
Fricative-Stop (11)	16/42	38%	Sonority fall

3.1.2 The Obligatory Contour Principle

The Obligatory Contour Principle (7), which prohibits identity, was originally proposed for tones (Leben 1973), and later applied to features and segments (Goldsmith 1976, McCarthy 1979, 1981, 1986), particular combination feature types (Padgett 1991), and syllables (Yip 1998).[5]

(7) The Obligatory Contour Principle (OCP): Identical phonological elements are prohibited within a domain.

The effect of the OCP emerges in Hebrew in various phonological elements, allowing different constraints of the OCP family to restrict word initial complex onsets (8). OCP^H (H for *homorganic*), an inviolable constraint of this type,

5 While originally defined with reference to adjacent phonological elements (on some level of representation), later studies have shown that the OCP holds also for non-adjacent elements, though the closer the elements, the stronger the effect (Pierrehumbert 1993, Rose 2000, Frisch et al. 2004, Yeverechyahu 2014, this volume).

prohibits adjacent consonants that share both place and manner of articulation (but may differ in voicing).[6] The relevant categories of *place* for OCP^{H} are labial, alveolar, palatal, and dorsal; the relevant categories for manner are stop, affricate, fricative, nasal, liquid and glide. OCP^{B}, which prohibits adjacent *labial* consonants regardless of their manner of articulation, is also never violated. The last constraint of this family, OCP^{S}, prohibits adjacent *sibilant* consonants, and is generally satisfied, with potential marginal exceptions.[7]

(8) a. OCP^{H} No adjacent consonants with same place and manner
b. OCP^{B} No adjacent labials
c. OCP^{S} No adjacent sibilants

The ensuing sections attend to all potential complex onsets and their distribution in Hebrew (see the appendix for the frequency of the individual attested clusters). The sections are organized by the sonority profile: obstruent-obstruent (§ 3.2), obstruent-sonorant (§ 3.3), and sonorant-sonorant (§ 3.4). We also note the properties of triconsonantal clusters (§ 3.5). In sections with many permissible clusters, we provide the matrix of the relevant consonants, including an example for each attested complex onset and a constraint for each empty cell, unless the gap is accidental. A summary of all possible combinations and their status is given in § 3.6.

The examples are native Hebrew, when available, and otherwise loanwords (marked with L). We do not include truncated imperative forms (Bolozky 1979, Bat-El 2002), such as ***ftaχ*** 'open!' (derived from *tiftáχ* 'you.MS.SG will open'), although they expand the inventory of complex onsets, because their degree of acceptability varies to a great extent; we do, however, consider them in the discussion. We consider a cluster *attested* both if it appears in derived and non-derived environments (*katan* → ***kt****an-á* 'small.FM', ***kt****av* 'handwriting'), as well as if it appears only in derived environments (*gaʃúm* → ***gʃ****umím* 'rainy.PL',

6 Co-occurrence of consonants in Semitic stems is restricted based on place of articulation (Greenberg 1950, McCarthy 1981, 1986). The first consonant in a root usually differs from the second in place of articulation, and the second usually differs from the third (except when the latter two are identical). Speakers of Modern Hebrew generalize this restriction to new forms, too (Berent & Shimron 1997, Berent et al. 2002, Yeverechyahu 2014).

7 OCP^{S} may also be a particular case of OCP^{H}, because all sibilants are coronal and are either fricatives (*s, z, ʃ*) or share a fricative component (*ʦ*). Nevertheless, OCP^{S} has exceptions (§ 3.2.3, § 3.2.4) in cases where the place is not identical (alveolar vs. palatal) or the manner is not identical (fricative vs. affricate), but crucially never in cases which strictly violate OCP^{H}. We therefore treat OCP^{S} as independent of OCP^{H}, and leave this debate for a separate occasion.

gʃav*), leaving the differences between them to another occasion.[8] All other clusters are *unattested*, such as the cluster *nm*, which violates *C_1SON, and is systematically broken by epenthesis in derived forms (e.g. *namúχ* → ***nemuχím* 'short.PL').

3.2 *Obstruent-obstruent onsets*

Obstruents participating in Hebrew complex onsets include six stops (*p, b, t, d, k, g*), six fricatives (*f, v, s, z, ʃ, χ*) and one affricate (*t͡s*). We do not include the glottal stop (*ʔ*) and fricative (*h*) in the discussion below. Insofar as historical glottal consonants surface phonetically, they never constitute a part of a cluster (Rosen 1957, Schwarzwald 2002, 2005, 2013, Faust this volume), neither derived nor underived (e.g. *katán* → ***kt**an-á* 'little.FM' vs. *ʔafóʁ* → ***ʔaf**oʁá* 'grey.FM'; ****ʔf**oʁa*). The Hebrew vocabulary also includes three borrowed obstruents (*ʒ, t͡ʃ, d͡ʒ*), which are rare, let alone in clusters.

3.2.1. Stop-stop onsets

Hebrew has a variety of clusters which consist of two stops (9). Including the affricate *t͡s* with the series of stops, out of the 49 potential onsets in the matrix below, only 19 (39%) are attested in Hebrew. We list below one example from each attested consonant combination. When a combination is unattested, we specify the reason for its absence with reference to universal constraints and language-specific gaps, which are due to historical change. These cells are shaded. Note that there are empty cells with more than one constraint due to overlapping effects.

(9) Complex onsets: stop-stop

	p	**b**	**t**	**d**	**t͡s**	**k**	**g**
p	OCP^{H}, OCP^{B} *C_2LABSTOP	OCP^{H}, OCP^{B} *C_2LABSTOP	**pt**iχút 'openness'	**pd**ijaá 'redemption'	**pt͡s**iá 'injury'	**pk**udá 'command'	**pg**iʃá 'meeting'
b	OCP^{H}, OCP^{B} *C_2LABSTOP	OCP^{H}, OCP^{B} *C_2LABSTOP	~**bt**iχút 'safety'	**bd**ajá 'fabrication'	**bt͡s**alím 'onions'	**bk**iút 'proficiency'	**bg**idá 'treason'
t	*C_2LABSTOP	*C_2LABSTOP	OCP^{H}	OCP^{H}	*AFFRICATE	**tk**ufá 'period'	**tg**uvá 'reaction'
d	*C_2LABSTOP	*C_2LABSTOP	OCP^{H}	OCP^{H}	*AFFRICATE	**dk**iʁá 'stabbing'	**dg**imá 'sample'
t͡s	*C_2LABSTOP	*C_2LABSTOP	*AFFRICATE	**t͡sd**aká 'charity'	OCP^{H}	*AFFRICATE	*AFFRICATE

8 It is difficult to determine which forms are 'non-derived' in a language with rich templatic morphology like Hebrew, and therefore we restrict here the term 'derived' to affixation.

(*cont.*)

	p	**b**	**t**	**d**	**t͡s**	**k**	**g**
k	*C_2LabStop	*C_2LabStop	**kt**ifá 'velvet'	**kd**eʁá 'cauldron'	**kt͡s**iʁá 'harvesting'	OCP^{H}	OCP^{H}
g	*C_2LabStop	*C_2LabStop	AG	**gd**ilá 'growth'	*Affricate	OCP^{H}	OCP^{H}

OCP^{B}	absent due to adjacent labials
OCP^{H}	absent due to adjacent consonants sharing place and manner of articulation
OCP^{S}	absent due to adjacent sibilants
*Affricate	absent due to dispreference for an affricate
*C_2LabStop	absent due to labial stop in C_2 (historical gap)
AG	accidental gap
~	inter-speaker variation

Before addressing each one of the constraints, it is important to note that we ignore here the effect of voicing assimilation (Bolozky 1978a, 1997, 2006, Barkai & Horvath 1978, Bat-El 1988, Kreitman 2008, Mizrachi 2016, this volume), which applies post-lexically and varies among registers, rate of speech, and the segmental properties of the consonants involved. As *devoicing* assimilation has the greatest effect (Mizrachi 2016, this volume), onset clusters consisting of [+voiced][-voiced] obstruents are less likely to be found in speech. In some cases, like ***bt͡s****alím* 'onions' and ***dk****iʁá* 'stabbing', the repair strategy is usually assimilation. In ***bt****iχút* 'safety', however, the repair is often epenthesis, obligatory for some speakers.

OCP^{H}, which prohibits adjacent consonants with identical place and manner of articulation, excludes 13 out of the 49 potential complex onsets in (9). This constraint is never violated, and all complex onsets violating OCP^{H} are amended via epenthesis (cf. ***kéʃeʁ*** → ***kʃaʁ-ím*** 'knots' vs. ***téde****ʁ* → ***ted****aʁ-ím/*****td****aʁ-im* 'frequencies'; Bat-El 1989). Clusters marked with OCP^{B} are also independently excluded by a prohibition on clusters consisting of two labial consonants.

The affricate *t͡s* appears in a very limited set of clusters with other stops. The resulting gaps are due to *Affricate, a dispreference for clusters with an affricate, whose basis is the cumulative effect of a complex segment (i.e. affricate) in a complex structure (i.e. complex onset). Although *t͡s* constitutes a single segmental unit in Hebrew (Bolozky 1980), it has an internal complex structure (Sagey 1986), containing both a stop-like and a fricative-like element. The effect of *Affricate is primarily observed in the case of a sonority plateau, which is independently dispreferred relative to a sonority rise. Note that although the absence of *tt͡s* and *dt͡s* may be attributed to OCP^{H} because *t͡s*

starts as a stop, this is not the case for the other gaps (*t͡ʂt, t͡ʂk, t͡ʂg, gt͡ʂ*). Impermissible clusters are, again, amended via epenthesis, though stop-affricate clusters may also be amended via stop deletion (e.g. ***tet͡ʂuʁa*** ~ ***t͡ʂuʁa*** 'formation'; ****tt͡ʂuʁa***). The choice between epenthesis and deletion is usually determined by the rate of speech, with epenthesis being associated with careful speech (Schwarzwald 2005, Bolozky 2006). The two borrowed affricates, *t͡ʃ* (e.g. *t͡ʃips* 'potato chips') and *d͡ʒ* (e.g. *d͡ʒins* 'jeans'), are not found in complex onsets, but are expected to be preserved, as in complex codas (e.g. *lant͡ʃ* 'lunch'), had such a loanword appeared.

*C_2LabStop, which excludes additional 10 complex onsets, is a restriction that reflects a language-specific gap, whereby labial stops do not appear in C_2 position, regardless of the quality of C_1. This gap is attributed to the process of post-vocalic spirantization attested in Biblical Hebrew (e.g. ***beːʔoː*** 'his house', *ləveːʔoː* 'to his house'; Blau 1919/2010). The complex onsets in native Hebrew words are reflexes of $_{\omega}[C_1əC_2$ sequences in Biblical Hebrew, and thus, due to postvocalic spirantization, Biblical Hebrew words did not have labial stops in C_2 (see Bolozky 1978a, Adam 2002, and Albert 2014, this volume for spirantization in Modern Hebrew and its sources in Biblical Hebrew). This historical gap is partly filled in Modern Hebrew by loanwords (e.g. ***spam*** 'spam'), which do not undergo epenthesis, as well as truncated imperatives (e.g. ***tba*** 'sue!', derived from the future form *titbá* 'you.MS will sue').

The absence of words with the cluster *gt* is probably an accidental gap (AG in 9), given the presence of *kt*, which has the same place contour, and of *dk*, which has the same voicing contour.

3.2.2. Stop-fricative onsets

We turn to stop-fricative clusters, given in (10). Out of the 42 potential stop-fricative onsets, 33 (79%) are attested.

(10) Complex onsets: stop-fricative

	f	**v**	**s**	**z**	**ʃ**	**χ**
p	OCP^{B}	OCP^{B}	**ps**ólet 'waste'	**pz**izút 'haste'	**pʃ**itá 'foray'	**pχ**adím 'fears'
b	OCP^{B}	OCP^{B}	**bs**oʁá 'news'	**bz**izá 'looting'	**bʃ**elá 'ripe.FM'	**bχ**iʁá 'choice'
t	**tf**uká 'output'	**tv**uná 'wisdom'	**ts**umá 'input'	**tz**uzá 'movement'	**tʃ**uvá 'answer'	**tχ**uná 'characteristic'

(*cont.*)

	f	v	s	z	ʃ	χ
d	**d**fiká 'bump (n)'	**d**vaʃ 'honey'	AG	AG	**dʃ**aním 'fertilizers'	**dχ**ifút 'urgency'
t͡s	**t͡s**fiʁá 'siren'	**t͡s**vitá 'pinch'	OCP^{S}	OCP^{S}	OCP^{S}	**t͡sχ**ok 'laughter'
k	**k**fafá 'glove'	**k**vut͡sá 'group'	**k**sil 'fool'	**k**zavím 'lies'	**k**ʃaʁím 'knots'	**k**χulím 'blue.PL'
g	**g**faním 'vines'	**g**vuʁá 'heroism'	**g**sisá 'dying'	**g**zaʁót 'sectors'	**gʃ**aʁím 'bridges'	**gχ**oním 'undersides'

OCP^{B} absent due to adjacent labials
OCP^{S} absent due to adjacent sibilants
AG accidental gap

Clusters consisting of two labials are excluded by OCP^{B}. There are no clusters with *t͡s* and another sibilant due to OCP^{S}, a constraint prohibiting any sequence of adjacent sibilants (see discussion of potential violations of this constraint in § 3.2.3 and § 3.2.4). The absence of *ds* and *dz* might be accidental (AG), although it is generally the case that alveolar stop-fricative clusters are dispreferred. The other two members of this class, *ts* and *tz*, are attested, but they are limited to cases in which *t* in C_1 is a nominal prefix (***t**zuzá* 'movement' cf. *zaz* 'moves').

3.2.3 Fricative-stop onsets

Fricative-stop onsets are limited mostly to clusters with a sibilant in C_1. Their possible combinations with stops are given in (11), where (L) stands for loanword. Out of 42 potential fricative-stop clusters, 16 (38%) are attested.

(11) Complex onsets: fricative-stop

	p	b	t	d	t͡s	k	g
f	OCP^{B} *C_1NonSib *C_2LabStop	OCP^{B} *C_1NonSib *C_2LabStop	*C_1NonSib	*C_1NonSib	*C_1NonSib	*C_1NonSib	*C_1NonSib
v	OCP^{B} *C_1NonSib *C_2LabStop	OCP^{B} *C_1NonSib *C_2LabStop	*C_1NonSib	*C_1NonSib	*C_1NonSib	*C_1NonSib	*C_1NonSib

(*cont.*)

	p	b	t	d	ʧ	k	g
s	**sp**oʁt (L) 'sport'	*C_2LabStop	**st**iʁá 'contradiction'	**sd**akím 'cracks'	**sʧ**éna (L) 'scene'	**sk**iʁá 'review'	**sg**iʁá 'closing'
z	*C_2LabStop	**zb**eng (L) 'sharp blow'	AG	**zd**oní 'malicious'	OCP^S	**zk**ikím 'follicles'	**zg**ugít 'glass panel'
ʃ	**ʃp**agát (L) 'split'	*C_2LabStop	**ʃt**ijá 'drinking'	**ʃd**idá 'looting'	OCP^S	**ʃk**ilá 'weighing'	**ʃg**iá 'error'
χ	*C_1NonSib *C_2LabStop	*C_1NonSib *C_2LabStop	**χt**iv 'spelling'	*C_1NonSib	*C_1NonSib	*C_1NonSib	*C_1NonSib

OCP^B	absent due to adjacent labials
OCP^S	absent due to adjacent sibilants
*C_1NonSib	absent due to non-sibilants fricative in C_1 (historical gap)
*C_2LabStop	absent due to labial stop in C_2 (historical gap)
AG	accidental gap

As before, the labial stops do not appear in C_2 position in native words (with the exception of truncation) due to *C_2LabStop. All combinations of two labials are also independently excluded by OCP^B.

The non-sibilant fricatives *f, v* and *χ* generally do not appear in C_1 of initial clusters due to a combination of historical gaps; we refer to this generalization as *C_1NonSib. Labial fricatives were absent word-initially in Biblical Hebrew, as these fricatives, as noted above, appeared only in post-vocalic position due to spirantization. Word initial *χ* is a reflex of the historical *ħ*, which has undergone post-guttural epenthesis, and therefore was always followed by *a*. Like other gaps rooted in the history of the language, this restriction does not trigger epenthesis. However, a non-sibilant in C_1 is possible in non-normative forms (e.g. ***χt****iv* 'spelling') as well as truncated imperatives (e.g. ***ft****ax* 'open!' derived from *tiftáχ* 'you.MS will open').

Hebrew has a large variety of sibilant-stop clusters. As opposed to the non-sibilant fricatives, sibilants did not participant in the above-mentioned historical spirantization and epenthesis. Clusters with *ʧ* and another sibilant are absent due to OCP^S, which prohibits sequences of adjacent sibilants. This constraint is violated in the loan word ***stʧ****ena* 'scene', though some speakers insert a vowel to break this clusters, i.e. ***setʧ****ena* (also, see § 3.2.4). The absence of *zt* might be an accidental gap (AG), given *st*, which has the same place contour, and *zk*, which has the same voicing contour.

3.2.4. Fricative-fricative onsets

Here, too, all attested clusters include a sibilant in C_1 (12). Out of 36 potential fricative-fricative combinations, 11 (31%) are attested.

(12) Complex onsets: fricative-fricative

	f	**v**	**s**	**z**	**ʃ**	**χ**
f	OCP^{H}, OCP^{B} *C_1NonSib	OCP^{H}, OCP^{B} *C_1NonSib	*C_1NonSib	*C_1NonSib	*C_1NonSib	*C_1NonSib
v	OCP^{H}, OCP^{B} *C_1NonSib	OCP^{H}, OCP^{B} *C_1NonSib	*C_1NonSib	*C_1NonSib	*C_1NonSib	*C_1NonSib
s	**sf**iná 'ship'	**sv**ivá 'environment'	OCP^{H}	OCP^{H}	OCP^{S}	**sχ**oʁá 'merchandise'
z	**zf**akím 'bird crops'	**zv**aá 'horror'	OCP^{H}	OCP^{H}	OCP^{S}	**zχ**ut 'right'
ʃ	**ʃf**ijút 'sanity'	**ʃv**il 'path'	~ʃsaím 'slits'	~ʃziʁá 'interweaving'	OCP^{H}	**ʃχ**uná 'neighborhood'
χ	*C_1NonSib	*C_1NonSib	*C_1NonSib	*C_1NonSib	*C_1NonSib	OCP^{H} *C_1NonSib

OCP^{B}	absent due to adjacent labials
OCP^{H}	absent due to adjacent consonants sharing place and manner of articulation
OCP^{S}	absent due to adjacent sibilants
*C_1NonSib	absent due to non-sibilants fricative in C_1 (historical gap)
~	inter-speaker variation

The constraints OCP^{H} and *C_1NonSib together exclude 23 of the logically possible clusters. Two additional clusters, *sʃ* and *zʃ*, are illicit due to OCP^{S}. The only violations of OCP^{S} in fricative-fricative clusters are restricted to clusters with *ʃ* in C_1, such as ***ʃziʁá*** 'interweaving' or ***ʃsaím*** 'slits'; however, even these clusters often undergo epenthesis (Bat-El 1989), as in ***ʃezufá*** 'tanned.FM', subject to interspeaker variation and rate of speech (Bolozky 2006).

3.3 *Obstruent-sonorant onsets*

The most common clusters cross-linguistically and within languages are those with an obstruent in C_1 and a sonorant in C_2 (Greenberg 1965), presumably due to the steep rise in sonority towards the syllable nucleus (Harris 1983, Clements 1990). As shown below, Hebrew has a rich inventory of clusters of this type. The set of Hebrew sonorant consonants includes nasals (*n, m*), liquids (*l, ʁ*) and glides (*j, w*), with *w* appearing only in loanwords.

3.3.1. Stop-sonorant onsets

Stops can be followed by nasals, liquids or glides in complex onsets (13). Out of 42 potential clusters, there are 31 (74%) attested.

(13) Complex onsets: stop-sonorant

	m	**n**	**l**	**ʁ**	**j**	**w**
p	OCP^{B}	**pn**ijá 'turn'	**pl**ugá 'squadron'	**pʁ**isá 'spreading'	*C_2GLIDE	OCP^{B} *C_2GLIDE
b	OCP^{B}	**bn**ijá 'construction'	**bl**itá 'bump'	**bʁ**aχá 'blessing'	*C_2GLIDE	OCP^{B} *C_2GLIDE
t	**tm**uná 'picture'	**tn**uvá 'yield n.'	**tl**uná 'complaint'	**tʁ**umá 'contribution'	**tj**utá (L) 'draft'	**tw**ist (L) 'twist dance'
d	**dm**ut 'image'	AG	**dl**ifá 'leakage'	**dʁ**aχím 'roads'	**dj**okán (L) 'portrait'	*C_2GLIDE
t͡s	**t͡sm**eím 'thirsty.PL'	**t͡sn**im 'toast'	**t͡sl**alím 'shadows'	**t͡sʁ**aχá 'scream'	**kj**u (L) 'cue'	*C_2GLIDE
k	**km**uʁá 'clergy'	**kn**isá 'entrance'	**kl**af 'card'	**kʁ**iá 'reading'	*C_2GLIDE	**kw**iʁ (L) 'queer'
g	**gm**ilá 'weaning'	**gn**evá 'theft'	**gl**imá 'cloak'	**gʁ**imá 'causation'	**gj**asót 'troops'	*C_2GLIDE

OCP^{B} absent due to adjacent labials
*C_2GLIDE absent due to glide in C_2 (historical gap)
AG accidental gap

Clusters that consists of two labials are excluded by OCP^{B}. Clusters with a glide in C_2 are rare in Hebrew and are mostly found in (old) loanwords (e.g. ***tj**utá* 'draft' from Aramaic, ***dj**okán* 'portrait' from Greek, ***tw**ist* 'twist dance' from English). The scarcity of clusters with *j* in C_2 originates from the historical deletion of glides in environments which serve as the basis of the later formation of clusters.[9,10] The labio-dorsal glide *w* appears only in loanwords in Modern

9 A primary source of clusters in Modern Hebrew is historical sequences of the form of $_{\omega}[C_1əC_2$, where ə was deleted at a later stage of Hebrew. Singleton glides in C_2 did not survive historically unless their preceding vowel was long. Thus, singleton glides in $_{\omega}[C_1əC_2$ environments were deleted before the stage of Hebrew in which a cluster could be formed.

10 We also note that the rarity of stop-glide clusters aligns with typology: such clusters are

Hebrew, so it is naturally not found in native clusters. We refer to this historical gap as *C_2GLIDE. Finally, the absence of *dn* is an accidental gap (AG), given the existence of *tn*, which only differs in the voicing of C_1, and *dm*, which only differs in the place of articulation of C_2.

3.3.2 Fricative-sonorant onsets

Similarly to stops, fricatives can be followed by nasals, liquids or glides (13). Out of the 36 potential fricative-sonorant onsets, 24 (66%) are attested.

(14) Complex onsets: fricative-sonorant

	m	**n**	**l**	**ʁ**	**j**	**w**
f	OCP^{B} *C_1NONSIB	OCP^{B} *C_1NONSIB	**fl**ájeʁ (L) 'leaflet'	**fʁ**ik (L) 'freak'	**fj**uz (L) 'fuse'	*C_1NONSIB *C_2GLIDE
v	OCP^{B} *C_1NONSIB	OCP^{B} *C_1NONSIB	**vl**adót 'newborns'	**vʁ**adím 'roses'	*C_1NONSIB *C_2GLIDE	*C_1NONSIB *C_2GLIDE
s	**sm**alím 'symbols'	**sn**aím 'squirrels'	**sl**aím 'rocks'	**sʁ**itá 'scratch'	**sj**ag 'restriction'	**sw**íta (L) 'suite'
z	**zm**an 'time'	**zn**avót 'tails'	**zl**igá 'leak'	**zʁ**izút 'agility'	*C_2GLIDE	*C_2GLIDE
ʃ	**ʃm**aʁím 'yeast'	**ʃn**ijá 'second'	**ʃl**atím 'signposts'	**ʃʁ**afʃím 'vermins'	**ʃj**aʁ 'remainder'	*C_2GLIDE
χ	**χm**aʁ (L) 'idiot'	**χn**un (L) 'nerd'	**χl**or (L) 'chlorine'	**χʁ**op (L) 'deep sleep'	*C_1NONSIB *C_2GLIDE	*C_1NONSIB *C_2GLIDE

OCP^{B} absent due to adjacent labials
*C_1NONSIB absent due to non-sibilants fricative in C_1 (historical gap)
*C_2GLIDE absent due to glide in C_2 (historical gap)

Fricative-sonorant clusters include the only exception to *C_1NONSIB, where a non-sibilant fricative appears in C_1 position in native words (excluding truncated and non-normative forms, § 3.2). The fricative that stands in this position is the voiced labial *v*, which appears in C_1 in words like ***v**ladót* 'newborns' and ***vʁ**adím* 'roses'; in both cases C_2 is occupied by a liquid. These are cases in which *v* corresponds to a historical glide *w*, which could appear word-initially in

typologically rare (Parker 2002), presumably due to the close similarity of glides and vowels.

Biblical Hebrew, unlike the spirantized counterpart of *b* (see §3.2.3). Still, *C_1NonSib is the historical basis of many of the gaps here. *C_2Glide independently excludes most of the fricative-glide clusters.

3.4 *Sonorant-sonorant onsets*

While there are complex onsets with sonority plateau consisting of two obstruents, there are hardly any with two sonorants. This is due to *C_1Son (§3.1.1), a prohibition against sonorants in C_1 of a complex onset (Rosen 1957, Schwarzwald 2002, 2005, 2013, Bolozky 2006). The very few exceptions are clusters with *m* in C_1, which are also more common cross-linguistically compared to other sonorant-sonorant clusters (Greenberg 1965, Kreitman 2008). The cluster *ml* in ***ml**aj* 'inventory' seems to be the only sonorant-sonorant cluster type that is robustly accepted by native Hebrew speakers. Other clusters with *m* in C_1, such as *mn* in ***mn**ajá* 'stock', *mʁ* in ***mʁ**iʁút* 'bitterness', and *ml* in ***ml**iá* 'plenum' are usually, but not always, broken by epenthesis, pronounced as ***men**ajá*, ***meʁ**iʁút*, and ***mel**iá*, respectively. In the non-native lexicon, there are a few loanwords with nasal-glide onsets (e.g. ***mj**ut* 'mute', ***nj**óki* 'gnocchi'), violating *C_1Son. All other sonorant-initial clusters are prohibited, even if they satisfy the Sonority Sequencing Principle in (4b) (**nl*, **nʁ*, **lʁ*, **ʁl*), and are broken in derived environments by epenthesis; e.g. *laván* → ***lev**an-á* *****lv**ana* 'white.fm' (cf. *katán* → ***kt**an-á* 'small.fm'), *ʁémez* → ***ʁem**az-ím*, *****ʁm**az-ím* 'hints' (cf. *kéʃeʁ* → ***kʃ**aʁ-ím* 'knots').

3.5 *Triconsonantal onsets*

Triconsonantal complex onsets are attested only in loanwords and are usually restricted to sequences of the form sibilant-stop-liquid (e.g. ***stʁ**íminŋ* 'streaming', ***skl**eʁózis* 'sclerosis', ***spʁ**ej* 'spray', ***ʃpʁ**itʦ* 'splash'). There is one triconsonantal complex onset that does not have a sibilant in C_1 position, ***χtj**aʁ* 'old man' (Schwarzwald 2005), but some speakers repair the cluster through epenthesis, ***χat**jáʁ*. There are only 8 (0.07%) words with triconsonantal complex onset in our data source (Bolozky and Becker 2006).

3.6 *Summary of complex onsets*

The matrix in (15) provides the status of all complex onsets based on all possible consonant combinations. Complex onsets that are attested in the native vocabulary (again, truncated imperatives are excluded) are marked as +; those that are attested only in loanwords are marked as $+^{L}$. Inter-speaker variation is marked by the addition of ~ to either of the former notations. Each absent cluster is labelled with the constraint responsible for its exclusion. Labelling is conducted in the following order. Son marks the clusters that are absent due

to violation of *C_1SON (see exceptions in § 3.4). Out of the remaining slots, OCP^H marks violations of the prohibition against adjacent consonants with the same place and manner of articulation; OCP^B marks all other slots with violations of the prohibition on two labials; OCP^S marks clusters absent due to violation of the prohibition on two sibilants (see exceptions in § 3.2.3, § 3.2.4). HG denotes historical gaps, including gaps due to *C_1NONSIB, *C_2LABSTOP and *C_2GLIDE. Clusters that are missing due to *AFFRICATE, a dispreference for affricates in a cluster, are marked as *AFF. All remaining slots, labelled AG, are possibly accidental gaps (see previous sub-sections). Consonants that do not appear in clusters at all, i.e. the glottals *ʔ* and *h* and the borrowed obstruents *ʒ*, *t͡ʃ* and *d͡ʒ*, are excluded.

The summary in (15) displays five accidental gaps (AG), four consisting of two coronals (*zt*, *ds*, *dz*, *dn*) and one which includes one coronal in C_2 (*gt*). These gaps could be the result of dispersion in complex onsets, given that the class of coronals is the largest among the place classes. Note also that there are no C*t* onsets where C is [+voiced] (Bolozky 2006), with the exception of *bt*, which, for some speakers, undergoes epenthesis like impermissible complex onsets with an initial sonorant.

4 Conclusions

The Hebrew inventory of syllable structures includes, apart from the unmarked CV syllable, more marked structures with codas and without onsets. Complex onsets (CCV …) occur mostly in nouns, but also in imperative verbs (e.g. ***kt**ov* 'write!') and denominative verbs (e.g. ***tʁ**in.**sf**éʁ* 'transferred'). Complex codas are restricted to verbs with the suffix *-t*, which denote 2nd person feminine in the past tense (e.g. *katá**vt*** 'you.2.FM wrote') and to a few loanwords from various periods of Hebrew (e.g. ***neft*** 'petroleum', ***baŋk*** 'bank'). Triconsonantal onsets and codas appear exclusively in loanwords (e.g. ***ʃprit͡s*** 'splash', ***tekst*** 'text'). There is no evidence for complex nuclei; Hebrew phonology does not provide evidence for vowel length contrast, and all diphthongs are analyzable in terms of a combination of one vowel and a glide in a consonantal position.

We reviewed the two primary constraints on complex onsets: the SSP and the OCP. Sonorants usually do not occupy C_1 (e.g. *laván* → ***le**van-á* /****l**vana* 'white.FM', cf. *katan* → ***kt**an-á* 'small.FM'), even in clusters that would otherwise satisfy the SSP (e.g. **nl*, **nʁ*). The only divergence is with *m*-initial clusters, which vary in acceptability (e.g. ***mn**ajá* ~ ***men**ajá* 'stock'). We also showed that the OCP, disallowing adjacent similar phonological elements, manifests itself in three ways: there is a prohibition against adjacent homorganic consonants

(15) Summary of complex onsets with two consonants

C_1 \ C_2	p	b	f	v	t	d	t͡s	s	z
p	OCP^{H}	OCP^{H}	OCP^{B}	OCP^{B}	+	+	+	+	+
b	OCP^{H}	OCP^{H}	OCP^{B}	OCP^{B}	+~	+	+	+	+
f	OCP^{B}	OCP^{B}	OCP^{H}	OCP^{H}	HG	HG	HG	HG	HG
v	OCP^{B}	OCP^{B}	OCP^{H}	OCP^{H}	HG	HG	HG	HG	HG
t	HG	HG	+	+	OCP^{H}	OCP^{H}	*AFF	+	+
d	HG	HG	+	+	OCP^{H}	OCP^{H}	*AFF	AG	AG
t͡s	HG	HG	+	+	*AFF	+	OCP^{H}	OCP^{S}	OCP^{S}
s	+^{L}	HG	+	+	+	+	+^{L}~	OCP^{H}	OCP^{H}
z	HG	+^{L}	+	+	AG	+	OCP^{S}	OCP^{H}	OCP^{H}
ʃ	+^{L}	HG	+	+	+	+	OCP^{S}	+^{L}~	+~
k	HG	HG	+	+	+	+	+	+	+
g	HG	HG	+	+	AG	+	*AFF	+	+
χ	HG	HG	HG	HG	HG	HG	HG	HG	HG
m	SON	SON	SON	SON	SON	SON	SON	SON	SON
n	SON	SON	SON	SON	SON	SON	SON	SON	SON
l	SON	SON	SON	SON	SON	SON	SON	SON	SON
ʁ	SON	SON	SON	SON	SON	SON	SON	SON	SON
j	SON	SON	SON	SON	SON	SON	SON	SON	SON
w	SON	SON	SON	SON	SON	SON	SON	SON	SON

+	attested in native vocabulary
+^{L}	attested only in loanwords
~	inter-speaker variation
SON	absent due to a sonorant in C_1
OCP^{H}	absent due to adjacent consonants sharing place and manner
OCP^{B}	absent due to adjacent labials
OCP^{S}	absent due to adjacent sibilants
*AFF	absent due to dispreference for an affricate
HG	historical gap
AG	accidental gap

ʃ	k	g	χ	m	n	l	ʁ	j	w
+	+	+	+	OCP^{B}	+	+	+	HG	OCP^{B}
+	+	+	+	OCP^{B}	+	+	+	HG	OCP^{B}
HG	HG	HG	HG	OCP^{B}	HG	$+^{L}$	$+^{L}$	$+^{L}$	OCP^{B}
HG	HG	HG	HG	OCP^{B}	HG	+	+	HG	OCP^{B}
+	+	+	+	+	+	+	+	+	$+^{L}$
+	+	+	+	+	AG	+	+	$+^{L}$	HG
OCP^{S}	*AFF	*AFF	+	+	+	+	+	HG	HG
OCP^{S}	+	+	+	+	+	+	+	+	$+^{L}$
OCP^{S}	+	+	+	+	+	+	+	HG	HG
OCP^{H}	+	+	+	+	+	+	+	+	HG
+	OCP^{H}	OCP^{H}	+	+	+	+	+	$+^{L}$	$+^{L}$
+	OCP^{H}	OCP^{H}	+	+	+	+	+	+	HG
HG	HG	HG	OCP^{H}	HG	$+^{L}$	$+^{L}$	$+^{L}$	HG	HG
SON	SON	SON	SON	SON	+~	+~	+~	$+^{L}$	OCP^{B}
SON	SON	SON	SON	SON	SON	SON	SON	$+^{L}$	SON
SON	SON	SON	SON	SON	SON	SON	SON	SON	SON
SON	SON	SON	SON	SON	SON	SON	SON	SON	SON
SON	SON	SON	SON	SON	SON	SON	SON	SON	SON
SON	SON	SON	SON	SON	SON	SON	SON	SON	SON

with the same manner of articulation (OCP^{H}), a prohibition against adjacent labials (OCP^{B}) and a prohibition against adjacent sibilants (OCP^{S}); the latter is minimally violated in loanwords (e.g. ***stsséna*** 'scene') and in some nouns with *ʃ* in C_1 (e.g. ***ʃziʁá*** 'interweaving'). Another set of clusters is absent due to historical gaps. These include gaps due to a historical post-vocalic spirantization, which governed an alternation between stops and non-sibilant fricatives; a historical epenthesis of *a* triggered by guttural consonants; and a historical deletion of intervocalic singleton glides.

All in all, Modern Hebrew has a rather rich inventory of syllable structures and complex onsets, but the distribution of the marked structures is limited, as expected. The relative frequency of the six marked syllable types (beyond CV and CVC) is as low as 13.4 % (see (1)), and the relative frequency of complex onsets is only 3.7 % (see (3)). Also with respect to the type of clusters, the better the sonority profile the higher the attested/potential (A/P) ratio (6).

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Appendix: frequency of word initial complex onsets in singular nouns

The table below provides the number of occurrences of each two-consonant combination as an initial onset. The data is drawn from the Living Lexicon of Hebrew Nouns (Bolozky & Becker 2006), which includes 123 cluster types and a total of 1189 occurrences of biconsonantal word initial complex onsets.

	n	%		n	%		n	%		n	%
pʁ	73	6.14	tl	12	1.01	t͡sn	7	0.59	bt͡s	3	0.25
tʁ	53	4.46	t͡sv	11	0.93	sl	7	0.59	ʃp	2	0.17
st	48	4.04	fʁ	11	0.93	sg	7	0.59	pd	2	0.17
kʁ	46	3.87	ʃf	10	0.84	zk	6	0.5	χl	2	0.17
kl	40	3.36	sv	10	0.84	pg	6	0.5	fj	2	0.17
pl	34	2.86	pt	10	0.84	bt	6	0.5	bs	2	0.17
gʁ	28	2.35	bd	10	0.84	zχ	6	0.5	df	2	0.17
bʁ	27	2.27	gd	9	0.76	pt͡s	6	0.5	zg	2	0.17
sχ	25	2.1	ʃʁ	9	0.76	kʃ	6	0.5	ʃg	2	0.17
ps	25	2.1	kt͡s	9	0.76	χʁ	6	0.5	bz	2	0.17
kv	22	1.85	pk	9	0.76	tk	6	0.5	ʃd	2	0.17
tχ	21	1.77	tʃ	9	0.76	gz	6	0.5	gs	1	0.08
gl	21	1.77	pn	9	0.76	zm	5	0.42	dk	1	0.08
ʃl	20	1.68	gm	9	0.76	dm	5	0.42	bg	1	0.08
bl	19	1.6	dj	8	0.67	zn	5	0.42	kw	1	0.08
kf	19	1.6	dv	8	0.67	zv	5	0.42	st͡s	1	0.08
gv	17	1.43	ks	8	0.67	t͡sm	5	0.42	tg	1	0.08
tf	15	1.26	fl	8	0.67	pχ	4	0.34	ʃz	1	0.08
dʁ	15	1.26	kd	8	0.67	km	4	0.34	tj	1	0.08
kt	15	1.26	ʁ	8	0.67	t͡sd	4	0.34	nj	1	0.08
sp	15	1.26	tn	8	0.67	t͡sf	4	0.34	kχ	1	0.08
kn	14	1.18	gn	8	0.67	pʃ	4	0.34	bn	1	0.08
ʃv	14	1.18	ʃk	8	0.67	sd	4	0.34	ml	1	0.08
ʃχ	14	1.18	sʁ	8	0.67	ts	3	0.25	kj	1	0.08
t͡sl	14	1.18	sk	8	0.67	bk	3	0.25	vʁ	1	0.08
sf	14	1.18	sn	8	0.67	tz	3	0.25	sw	1	0.08
sm	13	1.09	ʃn	8	0.67	t͡sχ	3	0.25	zb	1	0.08
ʃm	13	1.09	zʁ	7	0.59	sj	3	0.25	bʃ	1	0.08
ʃt	12	1.01	dχ	7	0.59	pz	3	0.25	zd	1	0.08
tv	12	1.01	dl	7	0.59	zl	3	0.25	ʃj	1	0.08
tm	12	1.01	bχ	7	0.59	dg	3	0.25			