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Metrically conditioned /a/-syncope in Modern Hebrew compounds

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Abstract
In Modern Hebrew, some, but not all, nominals exhibit obligatory /a/-syncope in open syllables if they are antepretonic in a simple (nominal) word. The same vowels optionally syncopate in any pretonic syllable in non-final members of compounds. Here we first show that syncope in compounds fills a gap in the typology of weak positions. We then propose a formal analysis in Gradient Harmonic Grammar (Smolensky and Goldrick 2016), which distinguishes between a weak /a/ and a strong /a/. Only the former undergoes syncope in both configurations; and only in non-compounds is it protected by a positional faithfulness constraint referencing the head foot of the prosodic word. Optionality in compounds is shown to follow from Base-Derivative faithfulness.

Keywords Gradient Harmonic Grammar · Metrical strength · Modern Hebrew · Positional faithfulness · Prosodic compounding · Syncope

1 Introduction

Metrically conditioned syncope refers to a phonological process of vowel deletion that occurs in metrically weak positions. In some languages the vowels that undergo syncope are those that occupy the dependent position of any foot in a word, e.g. Macushi Carib, Potawatomi (McCarthy 2008), Mojeño Trinitario (Rose 2019), as illustrated in (1) for Macushi Carib. In other languages, syncope applies only to vowels

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that occupy the dependent position of nonhead feet, as illustrated in (2) for Wampis (Peña Jaime 2015).[1]

(1) Macushi Carib vowel syncope (and iambic lengthening) (Kager 1997, 466; McCarthy 2008, 499)

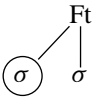
Underlying	Foot structure	Surface	
wanamari	(wa,naː)(maˈriː)	(w,naː)(mˈriː)	'mirror'
u-wanamari-ɾi	(u,waː)(na,maː)(riˈriː)	(,waː)(n,maː)(rˈriː)	'my mirror'
piripi	(pi,riː)(ˈpiː)	(,priː)(ˈpiː)	'spindle'

(2) Wampis vowel syncope (Peña Jaime 2015, 253, 274, 275)

Underlying	Foot structure	Surface	
arutama=na	(aˈru)(ta,ma)na	(aˈrut)man	'spirit of power=ACC'
wampisa-numa	(wamˈpi)(sa,nu)ma	(wamˈpis)num	'in Wampis'
arutama=ki	(aˈru)(ta,ma)ki	(aˈrut)mak	'only Arutam'

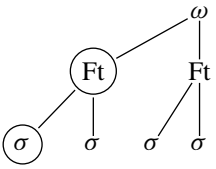
One way to account for the possible exemption of the head foot from syncope is to define the *domain of syncope* using the prosodic hierarchy and have syncope target *local nonhead* (henceforth "weak") prosodic constituents. A local weak constituent refers to the dependent prosodic constituent that is immediately dominated by the prosodic category that defines the domain of syncope. Under this view, in languages like Macushi Carib, the domain of syncope is the foot. Therefore, syncope targets all weak syllables of a word, because such syllables are the local weak constituents of feet, as illustrated in (3).

(3) Syncope targets weak syllables



In languages like Wampis, however, the domain of syncope is the prosodic word. Therefore, syncope targets all weak syllables of weak feet, because such feet are the local weak constituents of the prosodic word, as illustrated in (4).

(4) Syncope targets weak syllables of nonhead feet



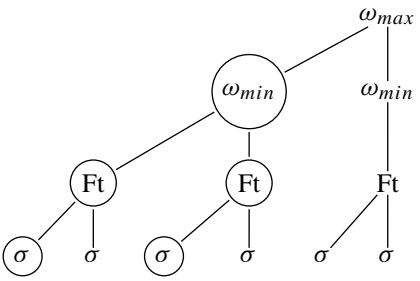
Research on the Prosodic Hierarchy has compiled evidence that prosodic categories, including the prosodic word, may be recursive (see, for recent work focusing on the prosodic word, Bennett 2018, Ito and Mester 2021, Weber 2022, and references cited therein).[2]

[1] In Wampis, both unstressed and stressed final vowels are deleted regardless of footing. In (2), we have not included even-numbered words with final apocope for the sake of simplicity.

[2] An alternative to recursivity at the level of the prosodic word is provided in Vogel (2021), who assumes a separate category called the composite group, previously referred to as the clitic group.

Assuming such structures, if syncope targets local weak prosodic constituents, it should be able to target *weak syllables of weak minimal prosodic words*. Weak minimal words are prosodic words that occupy the dependent position of a maximal prosodic word in prosodic compounding (also referred to as "balanced recursion," van der Hulst 2010). This is illustrated in (5).

(5) Syncope targets weak syllables of weak minimal words



In this paper, we show that this last prediction is indeed borne out by the syncope pattern affecting /a/ in Modern Hebrew nominal compounds, the first of its kind to be reported to the best of our knowledge. Besides its mere existence, two aspects of the phenomenon are intriguing. First, /a/-syncope also affects nominals outside compounds; but in compounds it is optional, whereas outside compounds it is obligatory. Second, many nominals never undergo /a/-syncope either in compounds or outside them. We develop an analysis of the data using Gradient Harmonic Grammar (Smolensky and Goldrick 2016). In this framework, as in Harmonic Grammar (Pater 2009), constraints are weighted rather than ranked; in addition, linguistic representations, including segments, can be gradient, that is, linked to numerically continuous levels of activity.

The rest of the paper is organized as follows. Section 2 presents the data. Section 3 reviews previous accounts of /a/-syncope in Modern Hebrew outside compounds (no previous formal account exists for syncope in compounds). Section 4 discusses the prosodic structure proposed for nominal compounds in Modern Hebrew. Section 5.1 introduces Gradient Harmonic Grammar, and Section 5.2 presents the analysis. Section 6 concludes the paper.

2 Data

In many uninflected Modern Hebrew nouns and adjectives, one finds a vowel /a/ in an open syllable immediately preceding the stressed syllable, henceforth the pretonic syllable. Stress in Modern Hebrew is predominantly final. Consequently, when a suffix is added, stress is pulled away from the base. In such a configuration, the /a/ would occupy an antepretonic position. However, one finds that many such /a/s syncopate. This instance of syncope, illustrated in (6), is obligatory for these items.

(6) Obligatory /a/-syncope in antepretonic position in non-compounds

a	paˈkid	‘clerk’	pkiˈd-im	‘clerk-PL’
b	kiʃaˈlon	‘failure’	kiʃloˈn-ot	‘failure-PL’
c	χadaˈʃot	‘news’	χadʃoˈt-i	‘of news (A)’
d	mataˈʁa	‘target’	matʁaˈt-i	‘my target’
e	mataˈna	‘gift’	matnaˈt-i	‘my gift’
f	aʁaˈts-ot	‘lands’	aʁts-oˈt-aj	‘my lands’
g	kaˈtan	‘small’	ktaˈn-im	‘small-PL’
h	ʃaˈχoʁ	‘black’	ʃχoˈʁ-a	‘black-PL’

Modern Hebrew also has N+N compounds (i.e. [ˌsug paˈkid] ‘type of clerk’), whose initial member is the syntactic head. However, the prosodic head is the second member. Items in the prosodic head behave exactly as in (6): syncope never targets a pretonic /a/ (7a, 7c), but does apply to /a/s that would occupy an antepretonic position (7b, 7d). Throughout this paper we use the IPA symbol for secondary stress to signal the lesser prominence of the stress in the first member of compounds. This is not intended to convey secondary stress such as in English *Alabama* [ˌæləˈbæmə]. We agree with most scholars that Modern Hebrew has no such secondary stress (see the acoustic study of Cohen et al. 2018).

(7) Obligatory /a/-syncope in antepretonic position in prosodic heads of compounds

a	paˈkid	‘clerk’	masˌkoʁet paˈkid	‘clerk’s salary’
b	pkiˈd-im	‘clerk-PL’	masˌkoʁet pkiˈd-im	‘clerks’ salary’
c	kiʃaˈlon	‘failure’	ˌsug kiʃaˈlon	‘type of failure’
d	kiʃloˈn-ot	‘failure-PL’	ˌsug kiʃloˈn-ot	‘type of failures’

Interestingly, the alternation between [a] and ∅ does occur in the *first* members of such compounds, which are the syntactic heads but the prosodic nonheads, as illustrated in (8). In this case, however, syncope is optional. Note, in addition, that the /a/s of such prosodic nonheads occupy a *pretonic* position—the position before the main stress of their own words, and yet they can be syncopated.[3]

(8) Optional pretonic /a/-syncope in prosodic nonheads of compounds

a	paˈkid	‘clerk’	ˌpkid∼paˌkid ˈmas	‘tax clerk’
b	kiʃaˈlon	‘failure’	kiʃˌlon∼kiʃaˌlon maʔaʁaˈχ-ot	‘system failure’
c	χadaˈʃ-ot	‘news’	χadˌʃ-ot∼χadaˌʃ-ot ˈbokeʁ	‘morning news’
d	mataˈʁa	‘target’	matˌʁat∼mataˌʁat ˈets	‘wooden target’
e	mataˈna	‘gift’	matˌnat∼mataˌnat pʁeˈda	‘departure gift’
f	aʁaˈts-ot	‘lands’	aʁˌts-ot∼aʁaˌts-ot aˈʁav	‘Arab countries’

In some words, the stressed [a] of the base becomes pretonic upon suffixation. Accordingly, it cannot be syncopated: cf. [oˈtsaʁ] ‘treasure,’ [otsaˈʁ-ot] ‘treasure-PL,’

[3] It is possible that the syncopated forms belong to a slightly higher register than the non-syncopated forms, but they can definitely occur in utterances that do not employ an especially high register. In addition, the likelihood of syncope might be affected by the frequency of the collocation; nevertheless, it is perfectly possible to employ a syncopated head in novel environments, e.g. [matˌʁat ˈtsemeʁ] ‘a woolen target.’ Interestingly, this syncope also occurs in A+N compounds (e.g. [ˌktan emuˈna] ‘of little faith,’ [ˌʃχoʁ ˈlev] ‘of black heart’ cf. (6g–6h)); it seems that it is even the preferred option in this case. However, as A+N compounds belong principally to a high register we do not include them in the discussion here.

*[ots'ʁ-ot]. However, as we have seen in (7b), even pretonic /a/s of the base may undergo syncope in the prosodic nonhead of compounds, as illustrated in (9). This is the only instance in which a vowel /a/ that is always stable outside compounds undergoes optional syncope.

(9) Optional pretonic /a/-syncope exclusive to prosodic nonheads of compounds[4]

a.	o'tsaʁ	'treasure'	ots‚ʁ-ot∼otsa‚ʁ-ot 'sin	'treasures of China'
			cf. otsa'ʁ-ot (*ots'ʁ-ot)	'treasure-PL'
b.	to'ʃav	'resident'	toʃ‚v-ej∼toʃa‚v-ej a'ʁad	'residents of Arad'
			cf. toʃa'v-im (*toʃ'v-im)	'resident-PL'
c.	mo'sad	'institution'	mos‚d-ot∼mosa‚d-ot χi'nuχ	'institutions of education'
			cf. mosa'd-ot (*mos'd-ot)	'institution-PL'

To be clear, all syncope-prone antepretonic /a/s are obligatorily syncopated, even those in the prosodic nonhead of compounds, as illustrated in (10). Notice that the masculine plural suffix has a different exponent in the syntactic head position of a compound, /-ej/ in (10a).

(10) Obligatory antepretonic /a/-syncope in prosodic nonheads of compounds

a.	pki'd-im (cf. pa'kid)	'clerk-PL'	pki‚d-ej 'mas	'tax clerks'
b.	kiʃlo'n-ot (cf. kiʃa'lon)	'failure-PL'	kiʃlo‚n-ot maʔaʁa'χot	'system failures'

Before we proceed, let us clarify the following point. It is common to distinguish between "compounds" and "constructs" in Modern Hebrew based on their level of semantic compositionality. For instance, compare a compound like [‚beged 'jam] 'swimsuit,' and a more compositional construct like [‚beged 'spoʁt] 'sports garment.' Borer (2013) provides several syntactic criteria to distinguish between the two constructions. However, prosodically both structures display the same stress pattern, with stress and /a/-syncope occurring on the first member. This similarity has also been pointed out by Borer (2013). In this paper we refer to both compounds and constructs as (prosodic) compounds.[5]

Finally, many /a/s do not participate in this alternation, as illustrated in (11). Crucially, these nouns do not alternate in compound structures either. Some of these forms were inherited from earlier stages of the language where the consonant after the putative target of syncope was a geminate that closed the syllable and hence blocked syncope. However, many of these items are innovations of Modern Hebrew, which has no geminate consonants.

(11) Non-syncopating nouns

a.	pa'kaχ	'supervisor'	paka'χ-im, *pka'χ-im	'supervisor-PL'
b.	ʃa'lit	'sovereign'	ʃali't-im, *ʃli't-im	'sovereign-PL'
c.	aga'da	'legend'	agada't-i, *agda't-i	'legendary'
d.	musa'ʁ-i	'moral (A)'	musaʁ-i'j-ut, *musʁ-i'j-ut	'morality'

[4]Penult syncope in compounds is in fact more common than usually considered. It occurs also for some /e/s that are stressed in the singular, e.g. [χa'veʁ] 'member,' [χav‚ʁej 'kneset] 'member of Parliament.'

[5]In a preliminary investigation for a University of Tel-Aviv term-paper, Nofar Rimon (p.c.) found that both constructs and compounds exhibit stress on the first member, though not to the same degree; stress is less prominent in the first member of compounds.

As far as we know, the data from Modern Hebrew compounds is reported here for the first time in the context of a phonological analysis of /a/-syncope (though some of the facts have been mentioned in the past, e.g. Siloni 2001). Any comprehensive analysis must distinguish the pretonic position in the prosodic nonhead of a compound (where syncope is optional) from the pretonic position elsewhere (outside compounds and in the prosodic heads of compounds), where syncope does not occur, and from the antepretonic position, in which syncope is obligatory regardless of the construction. Table 1 summarizes these facts from alternating nominals. Bold type indicates the site of potential syncope.

Table 1 Summary of syncope of /a/ in open syllables in Modern Hebrew nominals

	suffixed N	$N_{nonhead}$+$\mathbf{N}_{head}$	$\mathbf{N}_{nonhead}$+N_{head}
pretonic	never	never	optional
antepretonic	always	always	always

In addition, any analysis must explain why there are nouns like those in (11), which never exhibit syncope. Our goal in this paper is to account for all these facts. We provide the background to this analysis by briefly reviewing previous accounts of /a/-syncope in Modern Hebrew in the next section.

3 Previous accounts of /a/-syncope in Modern Hebrew

Previous accounts of /a/-syncope in Modern Hebrew have been exclusively concerned with nominals outside the compound construction. In Bat-El (2008), alternating forms are associated with two allomorphs: /pakid/ and /pkid/, and non-alternating forms are associated with a single underlying form: /pakaχ/. Furthermore, there is a constraint that requires all forms in a paradigm to have the same number of syllables. Bat-El (2008) claims that this uniformity requirement is less important than the anti-deletion constraint MAX: it cannot be complied with if that implies deleting stem material. The analysis works as follows. Consider the alternation between [paˈkid] and [pkiˈdim]. The allomorph /pkid/ allows one to maintain a suffixed form [pkiˈdim] with the same number of syllables as the singular [paˈkid] (which selects the allomorph /pakid/ to prevent a consonant cluster, an emergence of the unmarked effect). However, there is no available allomorph */pkaχ/, so the only way to get to *[pkaˈχim] in the plural in order to meet the paradigmatic requirement is syncope, and that is ruled out because of the high ranking of MAX. We would like to point out two drawbacks of this analysis. First, assuming two underlying representations for many nouns and adjectives which differ in exactly the same way (with /a/ and without it) misses a generalization and puts the burden on the lexicon. Second, this analysis cannot be extended to forms like [toʃ(a)ˌv-ej ˈsin] 'residents of China' because an allomorph without /a/ does not exist in SG-PL pairs; assuming one just for the compounds seems inelegant.[6]

[6]For more criticism of this account, as well as an account with ordered rules, see Rasin (2022).

Another account of /a/-syncope is Faust (2014a). He assumes an underlying long /aː/ in [paˈkaχ] and an underlying short /a/ in [paˈkid], which is then lengthened pretonically, but not antepretonically, [pkiˈdim]. The lack of lengthening in this position is interpreted phonetically as syncope. One advantage of this proposal is that there is no rampant allomorphy. At the same time, the proposed lexical and phonologically-derived lengths are not realized phonetically as such—a fact which raises the issue of the learnability of the analysis. Moreover, this analysis, like Bat-El's, does not easily extend to syncope in compounds, as in [toʃ(a)ˌv-ej ˈsin].

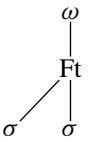
In this paper, we present an analysis that can be regarded as a version of Faust (2014a), but is couched within a framework closer to Bat-El's, namely Gradient Harmonic Grammar (Smolensky et al. 2014; Smolensky and Goldrick 2016). Before presenting the analysis, we first discuss in the next session the metrical structure of simple and compound nominals. Also, some of the constraints relevant to the analysis are given an interim formulation.

4 Prosodic structure

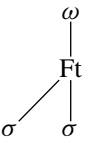
4.1 Simple nominals

Stress in the native vocabulary of Modern Hebrew is mostly final. We assume a single quantity-insensitive iambic foot aligned with the right edge of the prosodic word to account for final stress (Graf and Ussishkin 2003), as in (12). A straight line indicates headedness.

(12) Iambic feet in Modern Hebrew



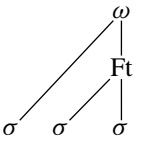
a. pa ˈkid 'clerk'



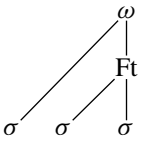
b. pa ˈkaχ 'supervisor'

It follows that the first lexical vowel of the word is unfooted when a suffix pulls stress away from the last syllable of the stem. We assume, as in McCarthy (2008), a two-step derivation to account for metrically conditioned syncope: first prosody is built, then syncope applies. This is possible in a derivational model like Harmonic Serialism. Therefore, when syncope applies, inputs contain prosodic structure inherited from a previous step of evaluation. The representations in (13) illustrate prosodic structures before syncope.

(13) Prosodic structure of suffixed forms before syncope



a. pa ki ˈdim ‘clerk-PL’



b. pa ka ˈχim ‘supervisor-PL’

To account for /a/-syncope in cases like /pakid-im/ → [pkiˈdim], we propose the markedness constraint formulated in (14), based on de Lacy (2006).

(14) *a_{weak} (to be reformulated)
Assign one violation mark for every unstressed [a] in an open syllable.

This constraint is based on the idea that unstressed positions are poor licensers of vowel features. Still, there is no syncope in /pakid/ → [paˈkid]. We claim that this is due to the unstressed [a] being part of the head foot of the prosodic word (see Sect. 1). In order to restrict syncope to the antepenult /pakid-im/ → [pkiˈdim], we therefore propose a positional version of the anti-deletion faithfulness constraint MAX, formulated in (15) (based on Lombardi 1998).[7] The lack of syncope in [pakaˈχim] will be returned to in the formal analysis.

(15) MAX/Head-of-ω (to be reformulated)
Assign one violation mark for every input segment parsed within the head of a prosodic word that has no output correspondent.

4.2 Nominal compounds

The second member of a N+N compound is metrically more prominent than the first member, e.g. [p(a)ˌkid ˈmas]. That is, the prosodic head in a compound is the rightmost element in Modern Hebrew, as opposed to its syntactic head, which is the initial element (see, for instance, Faust 2014b).

When pronounced in isolation, the compound [p(a)ˌkid ˈmas] and the N+A syntactic phrase [paˈkid ˈgas] ‘rude clerk’ seem to exhibit the same prosodic pattern: both have two lexical stresses, and the nuclear stress falls on the second element of the structure. Nevertheless, there are at least two reasons to assume that the first member in a compound is hierarchically more embedded in the prosodic structure than the first member in a N+A syntactic phrase. Since we know of no literature where such arguments are developed, we briefly provide two of them here.

First, the syncopated form of the first N member in a compound can never stand alone as a syntactic phrase, e.g. *[ˈpkid]. The same restriction holds in a N+A syntactic phrase, e.g. *[ˈpkid ˈgas]. The availability of syncope in the first member of compounds but not outside compounds or in the first member of a N+A syntactic phrase suggests that the first member of a compound is found in a weaker prosodic position.

[7] We will see that this constraint actually refers to the head of maximal prosodic words.

Second, stress retraction can occur in the first element of frequent compounds to avoid stress clash (forms in 16a), but this is not possible in N+A syntactic phrases (forms in 16b). The contrast in (16) follows if one assumes greater junctural distance between the items of a N+A syntactic phrase than between those of a compound.[8] Note that retraction occurs in both the first example in (16a), a construct according to the tests in Borer (2013), and the other two examples, which are compounds in Borer's terminology.

(16) Stress retraction in compounds

a. Compounds—retraction under clash

1st element	*retraction*	*no clash, no retraction*	
keˈʔev 'ache'	ˌkeʔev ˈʁoʃ 'headache'	keˌʔev ʃiˈnaim 'tooth ache'	(*ˌkeʔev ʃiˈnaim)
oˈʁeχ 'editor'	ˌoʁeχ ˈdin 'lawyer'	oˌʁeχ χadaˈʃot 'news editor'	(*ˌoʁeχ χadaˈʃot)
maˈtsav 'state'	ˌmatsav ˈʁuaχ 'mood'	maˌtsav tiˈsa 'flight mode'	(*ˌmatsav tiˈsa)

b. Phrases—no retraction across the board

1st element	*no retraction*	
keˈʔev 'ache'	keˈʔev ˈtov 'good ache'	(*ˈkeʔev ˈtov)
oˈʁeχ 'editor'	oˈʁeχ ˈʁa 'bad editor'	(*ˈoʁeχ ˈʁa)
maˈtsav 'state'	maˈtsav ˈtov 'good state'	(*ˈmatsav ˈtov)

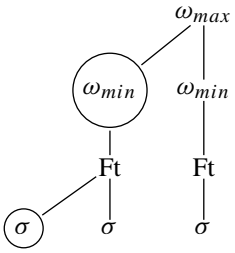
The retracted forms in (16) can also be realized with no stress at all on the first member.[9] This is in sharp contrast with the unretracted forms, a fact which lends further support to the transcription of the latter with two stresses. To account for these differences, we assume that N+A phrases contain two maximal prosodic words (which are simultaneously minimal). Nominal compounds, in contrast, are prosodically structured such that a single maximal word dominates two minimal words, as shown in (5) above and below in (17). The first minimal word in a prosodic compound is the dependent (weak) constituent of the maximal word. The /a/ of /pakid/ in a compound like the one illustrated in (17), even though it is footed, is prosodically very weak. It is parsed into the dependent syllable of the foot of the dependent minimal word.[10]

[8]The compounds in (16) can be made definite by a definite article on the second member. In this case, because the definite article is placed between the two stresses, one gets [maˌtsav haˈʁuaχ] 'the mood,' without stress retraction, not *[ˌmatsav haˈʁuaχ]. Note that the stress in the right-hand member of compounds cannot be tampered with: there can be no deletion (*[keˈʔev ʁoʃ] 'headache') and no protraction (*[maˌtsav ʁuˈaχ] 'mood'). Main stress is protected by faithfulness relativized to prosodic heads.

[9]There also seem to be instances of deaccentuation that are unrelated to stress clash in compounds, probably due to high frequency (e.g. [beged ˈjam] 'swimsuit,' cf. ['beged] 'garment,' with no stress in the first member). Further phonetic studies are needed to shed light on this issue.

[10]Another possibility is for the nonhead to be a simple foot dominated by the maximal prosodic word: $[(\text{p(a)ˌkid})_{Foot}[\text{ˈmas}]_{\omega}]_{\omega}$. The structure that we propose, however, performs better with respect to the constraint MATCH(Lex, ω), requiring that every lexical word match a prosodic word (Selkirk 2011).

(17) Weakness of unstressed footed [a] in the first member of a compound (‘tax clerk’)



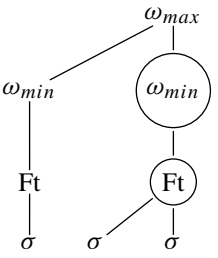
p(a) ˌkid ˈmas

The [a] of [paˌkid] in (17) can be targeted by syncope if the positional faithfulness constraint presented in (15) is formulated to refer to maximal prosodic words, as in (18). Because the [a] of [paˌkid] in (17) is parsed within the dependent of the maximal prosodic word, that is, the minimal word of the compound, positional faithfulness cannot exempt this vowel from syncope.

(18) MAX/Head-of-ω_{max}
Assign one violation mark for every input segment parsed within the head foot of a maximal prosodic word that has no output correspondent.[11]

Unless protected by (18), an unstressed /a/ in an open syllable is not licensed in Modern Hebrew, i.e. when it is either unfooted or footed but parsed within the dependent position of a maximal prosodic word. Elsewhere, i.e. within the head foot of a maximal word, it is always licensed. This is the case of [paˈkid] in isolation, or when it is the prosodic head of a compound. The latter configuration is illustrated in (19) with [ˌsug paˈkid] ‘clerk type,’ in which the [a] of [paˈkid] never undergoes syncope.

(19) Unstressed footed [a] in the second member of a compound (‘clerk type’)



ˌsug pa ˈkid

In this section, we have proposed that unstressed /a/ in an open syllable is protected from syncope only when it is parsed within the head foot of the maximal prosodic

[11] This constraint is novel in that MAXIMALITY targets a head foot rather than just the stressed syllable. Analogous constraints at the foot level were recently proposed in Köhnlein (2016).

word (e.g. [(paˈkid)] 'clerk'); syncope is obligatory in inflected forms in which /a/ would otherwise occupy the antepretonic position (e.g. [(pkiˈd-im)] *[pa(kiˈd-im)] 'clerk-PL,' see (6)). This is also why syncope may target a footed, pretonic [a] in the nonhead of a prosodic compound (e.g. [(ˌpkid)∼(paˌkid) (ˈmas)] 'tax clerk,' see (8), (9)). However, we have also seen that in the latter case syncope is not obligatory. Moreover, in many items /a/ never undergoes syncope, within or outside compounds (e.g. [pa(kaˈχ-im)] *[(pkaˈχ-im)] 'supervisor-PL,' see (11)). We return to these issues in the next section, where we discuss the computation behind syncope, and specifically what speakers arguably learn in order to derive variation of syncope in compounds.

5 Analysis

5.1 Gradient Harmonic Grammar

In Gradient Harmonic Grammar (Smolensky et al. 2014; Smolensky and Goldrick 2016), constraints are weighted rather than ranked, as in Harmonic Grammar, and representations can be gradient: a segment can be underlyingly weaker than it needs to be in order to be realized.

Let us first illustrate how Harmonic Grammar works without gradient representations. In Harmonic Grammar, violations are multiplied by the weight of constraints, and the results are then summed. This gives a harmony score. The closer the score is to 0, the more harmonic the candidate. Unlike classic Optimality Theory, in Harmonic Grammar constraint violation can be cumulative: two constraints B and C, each with a weight smaller than another constraint A, can block the effect of constraint A if the sum of their weights is greater than that of A. This situation is referred to as a "gang" effect. To illustrate, consider Japanese loanword devoicing (Pater 2009, based on Kawahara 2006). A sequence of two voiced obstruents is tolerated in Japanese loanwords despite a violation of OCP-VOICE in (20a). In (20b), a voiced obstruent geminate is preserved despite a violation of *VOICE-GEM. However, an underlying voiced geminate devoices after another voiced obstruent (20c). This is so because although OCP-VOICE and *VOICE-GEM each have a weight that is smaller than the weight of IDENT-VOICE, the sum of their violations makes the candidate with geminate devoicing more harmonic.

(20) Japanese loanword devoicing as cumulative constraint interaction (Pater 2009)

a. /bobu/ → [bobu] 'Bob'

bobu	IDENT-VOICE$^{1.5}$	OCP-VOICE^{1}	H
a. ☞ bobu		−1	−1
b. bopu	−1		−1.5

b. /webːu/ → [webːu] ‘web’

	webːu	IDENT-VOICE$^{1.5}$	*VOICE-GEM^{1}	H
a. ☞	webːu		−1	−1
b.	wepːu	−1		−1.5

c. /dogːu/ → [dokːu] ‘dog’

	dogːu	IDENT-VOICE$^{1.5}$	*VOICE-GEM^{1}	OCP-VOICE^{1}	H
a.	dogːu		−1	−1	−2
b. ☞	dokːu	−1			−1.5

Gradient Harmonic Grammar combines Harmonic Grammar with gradient representations. Assume that segments need to be of the strength or activity level 2 to be realized, but can be lexicalized with lesser strength, say 1.[12] A segment with the strength of 1 violates DEP to the strength of 1 if it is realized, because strength is added to it; and it violates MAX to the strength of 1 if it is syncopated. However, a segment with the strength of 2 does not violate DEP if it is realized, because no strength is added to it; and it violates MAX to the strength of 2 if it is syncopated. Now imagine a language in which codas are avoided, there is a strong /p_2/ and a weak /p_1/, and the constraints NO-CODA, MAX and DEP have the weights 3, 2, and 1, respectively. In such a language, the constraint NO-CODA will be satisfied differently depending on the lexical strength of the consonant. In the presence of a weak /p_1/, NO-CODA will be satisfied by means of deletion, whereas in the presence of a strong /p_2/, NO-CODA will be satisfied by means of epenthesis, as illustrated in (21). Note that markedness constraints like NO-CODA assign −2 violations because 2 is the activity level of all output segments.

(21) Codas avoided non-uniformly depending on the strength of consonants

a. /tap$_1$/ → [ta]

	tap$_1$	NO-CODA^{3}	MAX^{2}	DEP^{1}	H
a.	tap$_2$	−2		−1	−7
b.	tap$_2$i$_2$			−3	−3
c. ☞	ta		−1		−2

b. /tap$_2$/ → [tap$_2$i$_2$]

	tap$_2$	NO-CODA^{3}	MAX^{2}	DEP^{1}	H
a.	tap$_2$	−2			−6
b. ☞	tap$_2$i$_2$			−2	−2
c.	ta		−2		−4

[12] We use natural numbers for practical reasons. We adopt the simplest take on GEN whereby all output segments are of activity level 2, meaning full realization.

In the next subsection we show how the distinction between two different lexical /a/s, one with an activity level 1, /a_1/, and another one with an activity level 2, /a_2/, can derive the differences between /pakid/ and /pakaχ/ with respect to /a/-syncope.

5.2 Formalization

In this analysis, we adopt the principles laid out in the Harmonic Serialism analysis of syncope in McCarthy (2008), in which constraint rankings remain consistent throughout a phonological derivation defined by gradualness (GEN can only introduce one change at a time, where one change means one violation of a faithfulness constraint). The derivation converges when no harmonic improvement is possible, that is, when the fully faithful parse of the latest input is the optimal candidate.

According to McCarthy (2008), stress assignment precedes syncope. This derives from ranking the constraint WORDCONDITION, which requires every morphosyntactic word to be parsed into a prosodic word, above IDENT(stress) and EXHAUSTIVITY(WORD). WORDCONDITION entails the concurrent building of feet because every prosodic word has a head foot. IDENT(stress) must exist in GEN because in some languages stress is a contrastive property. In McCarthy's analysis IDENT(stress) is violated when foot structure in the output is not present in the input. EXHAUSTIVITY(WORD) is violated when a prosodic word node directly dominates a syllable. We illustrate in (22) the first step of the derivation, in which stress is assigned. We abstract away from the constraints responsible for the shape of feet and their alignment in Modern Hebrew (ALIGN-Right(foot, word) and IAMB), as well as lexical activity levels associated with vowels. In this respect, we assume that at the first step of the derivation in which metrical structure is built, activity levels cannot be altered because both syncope (= deletion of strength) or full realization (= insertion of strength to weak segments) count as separate steps and cannot co-occur.

(22) /pakid-im/ → [pa(ki.ˈdim)]

pakid-im	WDCOND^3	IDENT(stress)^1	EXH(WD)^1	*H*
a. ☞ pa(ki.ˈdim)		−1	−1	−2
b. pa.ki.dim	−1			−3

As in McCarthy (2008), the input to the relevant step of the derivation where syncope can take place is a prosodified form like the one in (22a). We now concentrate on the second step of the derivation. In this second step, segments with deficient strength are subject to either syncope (loss of activity) or strengthening (enhancement of activity).

Before discussing the tableaux, we first formulate the five constraints used in this analysis (23). Recall that one violation of a markedness constraint like *a_{weak} translates into a penalty of −2 because all output segments have the activity level 2. Adding strength is a violation of DEP, whereas syncope incurs a violation of MAX; these constraints assign a penalty of −1 or −2 depending on the underlying activity level of the segment. We further propose the positional version of MAX argued for in Sect. 4.1, and also an asymmetric base-derivative version of this constraint in which

the base refers to each of the outputs corresponding to the individual members of a compound.[13]

(23) Constraints

a. *a_{weak}
For every unstressed [a] in an open syllable of activity α, assign a penalty of $-\alpha$.

b. DEP
Assign a penalty of $-\alpha$ for every α amount of activity added.

c. MAX
Assign a penalty of $-\alpha$ for every α amount of activity removed.

d. MAX/Head-of-ω_{max}
Assign a penalty of $-\alpha$ for every α amount of activity removed in the head of a maximal prosodic word.

e. MAX-BD (based on Benua 1997)
Assign a penalty of $-\alpha$ for every α amount of activity in the derivative that is missing from the output base.

5.2.1 Obligatory syncope of unfooted [a] in simple nominals

As can be seen in the tableaux in (24), all faithfulness constraints have a weight of 2, whereas the markedness constraint *a_{weak} has a weight of 0.5. Syncopating a weak /a/ (with an activity level of 1) that is parsed within the head of the prosodic word, that is, the foot, incurs a violation of both context-free MAX and context-sensitive MAX/Head-of-ω_{max}. This gives a harmony score of -4 to candidate (b) in (24a). Realizing the weak [a], that is, adding strength to it, incurs a violation of DEP and *a_{weak}. The sum of the two constraints gives a harmony score of -3, so the non-syncopated candidate is more harmonic than the syncopated candidate. However, when the weak [a] is unfooted (24b), that is, not parsed within the head of the prosodic word, syncopating this vowel only incurs a violation of context-free MAX. In this case, the syncopated candidate is more harmonic than the non-syncopated candidate.

(24) Syncope of weak /a_1/ when unfooted

a. (pa_1.ˈkid) → (pa_2.ˈkid)

	(pa_1.ˈkid)	DEP^2	MAX^2	MAX/Head-of-$\omega_{max}{}^2$	*$a_{weak}{}^{0.5}$	H
a. ☞	(pa_2.ˈkid)	-1			-2	-3
b.	(ˈpkid)		-1	-1		-4

b. pa_1(ki.ˈdim) → (pki.ˈdim)

	pa_1(ki.ˈdim)	DEP^2	MAX^2	MAX/Head-of-$\omega_{max}{}^2$	*$a_{weak}{}^{0.5}$	H
a. ☞	(pki.ˈdim)		-1			-2
b.	pa_2(ki.ˈdim)	-1			-2	-3

[13] A base-derivative constraint is well motivated for compounds, which are derived forms.

Moving on to unsyncopatable /a/ vowels, recall that these are not deficient underlyingly: they are lexicalized with activity level 2. As a result, they do not require boosting in order to be realized. Consider (25a), with such a vowel in the pretonic position. Candidate (a) in (25a) only violates *a_{weak}; it does not violate DEP because no strength needs to be added to realize this vowel. Upon suffixation (24b), and because DEP is irrelevant when strong /a/ is involved, the syncopated candidate is ruled out because MAX has more weight than *a_{weak}.

(25) No syncope with strong /a_2/

a. (pa_2.ˈ$ka\chi$) → (pa_2.ˈ$ka\chi$)

	(pa_2.ˈ$ka\chi$)	DEP^2	MAX^2	MAX/Head-of-$\omega_{max}{}^2$	*$a_{weak}{}^{0.5}$	H
a. ☞	(pa_2.ˈ$ka\chi$)				−2	−1
b.	(ˈ$pka\chi$)		−1	−1		−4

b. pa_2(ka_2.ˈχim) → pa_2(ka_2.ˈχim)

	pa_2(ka_2.ˈχim)	DEP^2	MAX^2	MAX/Head-of-$\omega_{max}{}^2$	*$a_{weak}{}^{0.5}$	H
a. ☞	pa_2(ka_2.ˈχim)				−4	−2
b.	(pka_2.ˈχim)		−2		−2	−5
c.	(pa_2k.ˈχim)		−2		−2	−5

5.2.2 Optional syncope of footed [a] in compounds

We attribute the variation [paˌkid∼ˌpkid ˈmas] in compounds to the asymmetrical output-output constraint MAX-BD, in which the base refers to the output of the individual members of a compound, and the derivative to the compound. Free variation is formally expressed as a tie between candidates, that is, when they receive the same harmony score. As can be seen in (26), syncope targets the unstressed footed [a] of the first member of the compound. MAX/Head-of-ω_{max} is not violated because the foot that parses that vowel is not the head of the maximal prosodic word but rather the head of the weak minimal word. This alone could trigger syncope in these cases. However, in this configuration, the constraint MAX-BD, which has the same weight as *a_{weak}, comes into play. The syncopated candidate in (26b) violates this constraint, and this creates a tie between the two candidates, hence the free variation.

(26) /pa$_1$kid mas/ → [(pa.$_2$ˌkid)∼(ˌpkid) (ˈmas)]
Base = [(pa$_2$.ˈkid)]

{{(pa$_1$.ˌkid)}ω_{min} {(ˈmas)}ω_{min}}ω_{max}	DEP^2	MAX^2	MAX/Head-of-ω_{max}^{2}	*a$_{weak}$$^{0.5}$	MAX-BD$^{0.5}$	*H*
a. ☞ {{(pa$_2$.ˌkid)}ω_{min} {(ˈmas)}ω_{min}}ω_{max}	−1			−2		−3
b. ☞ {{(ˌpkid)}ω_{min} {(ˈmas)}ω_{min}}ω_{max}		−1			−2	−3

In contrast, there is no tie and therefore no variation in the derivation of [pa.ˌkaχ ˈmas], illustrated in (27). This is due to the fact that DEP is irrelevant in this case.

(27) /pa$_2$.kaχ mas/ → [(pa$_2$.ˌkaχ) (ˈmas)] ‘tax supervisor’
Base = [(pa$_2$.ˈkaχ)]

{{(pa$_2$.ˌkaχ)}ω_{min} {(ˈmas)}ω_{min}}ω_{max}	DEP^2	MAX^2	MAX/Head-of-ω_{max}^{2}	*a$_{weak}$$^{0.5}$	MAX-BD$^{0.5}$	*H*
a. ☞ {{(pa$_2$.ˌkaχ)}ω_{min} {(ˈmas)}ω_{min}}ω_{max}				−2		−1
b. {{(ˌpkaχ)}ω_{min} {(ˈmas)}ω_{min}}ω_{max}		−2			−2	−5

Importantly, this analysis can derive syncope in the suffixed compound head even if the vowel /a/ of the item bears main stress in the unsuffixed, non-compound form. As illustrated in (28), there is also a tie in the derivation of [to(ʃa$_2$.ˌvej)∼(toʃ.ˌvej) (ˈsin)] (singular unsuffixed /toʃa$_1$v/ → [taʃa$_2$v]). However, as opposed to what happens in /pakid/, the plural form of /toʃa$_1$v/ has no syncope: [to(ʃa$_2$.ˈvim)]. This is because in [to(ʃa$_2$.ˈvim)] the [a] is parsed within the foot, the head of the prosodic word. In the compound plural, however, the [a] is no longer protected by MAX/Head-of-ω_{max}.

(28) /toʃa$_1$v-ej sin/ → [to(ʃa$_2$.ˌvej)∼(toʃ.ˌvej) (ˈsin)] ‘residents of China,’ cf. [(to.ˈʃav)] ‘resident,’ [to(ʃa.ˈvim)] ‘residents’
Base = [to(ʃa$_2$.ˈvim)]

$\{\{\text{to}(\text{ʃa}_{1}.\text{ˌvej})\}\omega_{min}\ \{(\text{ˈsin})\}\omega_{min}\}\omega_{max}$	DEP^2	MAX^2	MAX/Head-of-$\omega_{max}{}^2$	$*\text{a}_{weak}{}^{0.5}$	MAX-BD$^{0.5}$	H
a. ☞ $\{\{\text{to}(\text{ʃa}_{2}.\text{ˌvej})\}\omega_{min}\ \{(\text{ˈsin})\}\omega_{min}\}\omega_{max}$	−1			−2		−3
b. ☞ $\{\{(\text{toʃ}.\text{ˌvej})\}\omega_{min}\ \{(\text{ˈsin})\}\omega_{min}\}\omega_{max}$		−1			−2	−3

6 Conclusions

Adopting the standard assumption that compounds are recursive prosodic structures, an unstressed vowel in the weak branch of a compound is predicted to be more susceptible to syncope than the same vowel in a weak position of the compound head. However, to the best of our knowledge, no such cases have been described in the phonological literature. In this paper, we proposed that this is the correct view of the optional /a/-syncope attested in Modern Hebrew compounds. Outside the compound configuration, syncopatable vowels syncopate unless protected by a positional faithfulness constraint that militates against the deletion of segments in the head foot of maximal words. Non-final members of compounds also have feet and main stress, but these feet do not head the maximal word; for this reason, their weak branches are not protected by this specific type of positional faithfulness. As a result, like unfooted /a/s outside compounds, footed /a/s can syncopate in non-final members within compounds.

Two questions arise for an analysis of the specific facts of Modern Hebrew. First, why do some vowels resist syncope in either configuration? And second, why is syncope obligatory outside compounds, but optional within compounds? Following Gradient Harmonic Grammar, we maintained that Modern Hebrew involves two types of /a/ vowels: strong and weak. Only weak ones can be syncopated without too high a cost. As for the optionality in compounds, it is accounted for by the fact that compounds are derived entities, as evidenced by their prosodic structure. Accordingly, faithfulness to the output forms of compound members outside the compound configuration is expected. In the present case, this faithfulness constraint militates against syncope in compounds (but not in simple nominals, including suffixed ones), leading to a tie between the syncopated and non-syncopated candidates. Importantly, the present account exceeds previous ones in empirical coverage, in that it applies both within and without compounds.

It remains to be seen whether phenomena from other languages join /a/-syncope in Modern Hebrew in exhibiting special weakness in compound nonheads, thereby confirming the typological predictions with which we opened this paper.

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