The Emergence of Secondary Stress in Hebrew Phrases

Nofar Rimon

Background

- The stress pattern of Hebrew has concerned many scholars over the years. Of particular interest is the question whether Hebrew has secondary stress, and if so – what its domain is.

- The sole acoustic study on Hebrew stress examined prosodic words only (Cohen et al., 2018). Phrases were not examined, even though this is the level at which we would expect to see stress shift and secondary stress (based on evidence from Biblical Hebrew).

- Theories of the inter-relations between syntactic structure and prosody were successful in explaining several phenomena, such as stress shift and ambiguity resolution (Cinque, 1993; Selkirk, 2011). Examining the stress pattern of Hebrew phrases in light of syntax-prosody mapping theories would yield different predictions, which could be tested experimentally.

- The current study examined the stress pattern of 3 types of Hebrew phrases — compounds, construct states and N+A constructions, which have different syntactic structures, to see if this difference also reflects in prosodic structure.

INTRODUCTION

N+N constructions

- Hebrew has 2 types of N+N constructions: compounds and construct states.

- **Construct states:** phrases that contain 2 (or more) nouns with some dependency relation between them, usually expressing possession or modification (e.g., wood table, kitchen towel).

- **Compounds:** phrases that contain 2 nouns only, a closed subgroup of construct states which are more cohesive. They are characterized by non-compositionality, and could potentially be interpreted as a single word, sometimes even written as such (e.g., *beged jam*, suit sea, 'swimsuit').

In the literature…

- **Bat-El (1993):** There is secondary stress which falls on the syllable bearing primary stress in the first element of the construction.
- **Graf & Ussishkin (2003)**: Rhythmic secondary stress is assigned iteratively to every other syllable to the left of the main stress.
- **Borer (2008):** Hebrew compounds and construct states have one primary stress only, which falls on the stressed syllable of the rightmost noun of the construction.
- **Cohen et. al (2018):** There is no phonetic realization of secondary stress in (single words in) Modern Hebrew.
- **Bolozky (2019):** Even though no acoustic evidence for secondary stress in MH was found, Hebrew speakers claim to perceive it due to a general tendency for automatic rhythmic alternation of stressed syllables with unstressed ones.

Cohen et al. (2018)

The sole acoustic study on Hebrew stress found no evidence for secondary stress in single words based on duration, intensity and pitch.

[mandaˈʁ̞ina]

[ˈkontʁ̞abas]

However, duration was found to be the most reliable acoustic cue for stress in Hebrew.

Construct state stress in Biblical Hebrew

Construct states in Biblical Hebrew exhibit secondary stress via cantillation (diacritics that mark the manner of chanting the biblical text and syntactic interpretation) when both nouns are conjoined with a maqqef (similar to the Latin hyphen).

מַלְכַּת־שְׁבָא (1 Kings, 10:4)

malkat ʃəḇɔ
queen.CS Sheba

‘The queen of Sheba’

Research Questions

- Q1: Compounds, construct states and N+A constructions have different syntactic structure. Are the syntactic differences among these constructions reflected in different prosodic structures?

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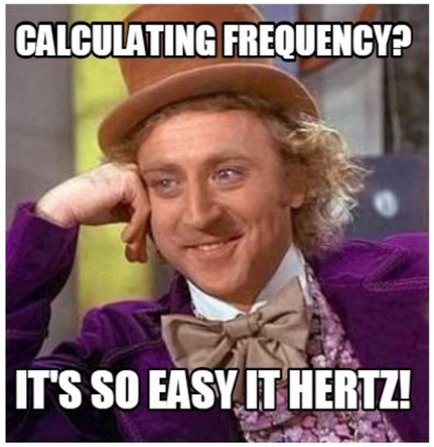
- Q3: Does frequency play a role in the prosodic structures both within and between these construction groups?



Research Questions

- Q1: Compounds, construct states and N+A constructions have different syntactic structure. Are the syntactic differences among these constructions reflected in different prosodic structures?
- Q2: Does Hebrew have secondary stress at the phrase level?
- Q3: Does frequency play a role in the prosodic structures both within and between these construction groups?
- Q4: Are the attested prosodic structures predicted by theories of syntax-prosody correspondence?

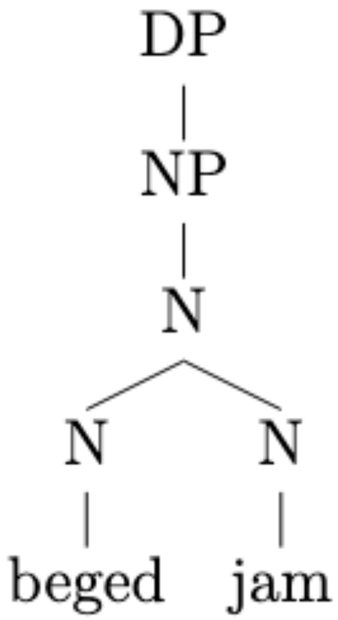
Why is that interesting/important?

Answering these questions will contribute to our typological knowledge of stress systems and to our understanding of the relations between syntax, frequency, stress, and prosody.

SYNTAX-PROSODY CORRESPONDENCE THEORIES

The syntactic structures (Allen, 1979; Borer et al., 1988; Cinque, 1993; Williams, 1981)

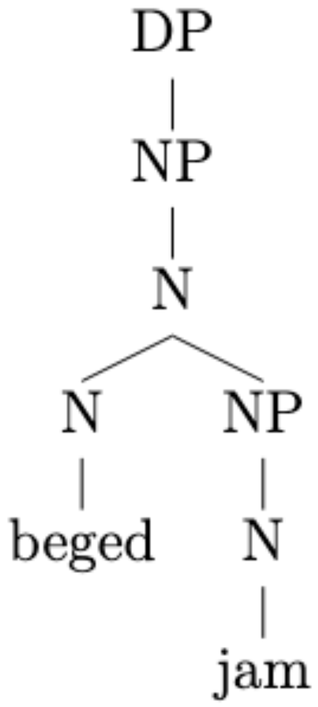
Classic compounds



"Hebrew compounds are identical to English ones".

suit sea
'swimsuit'

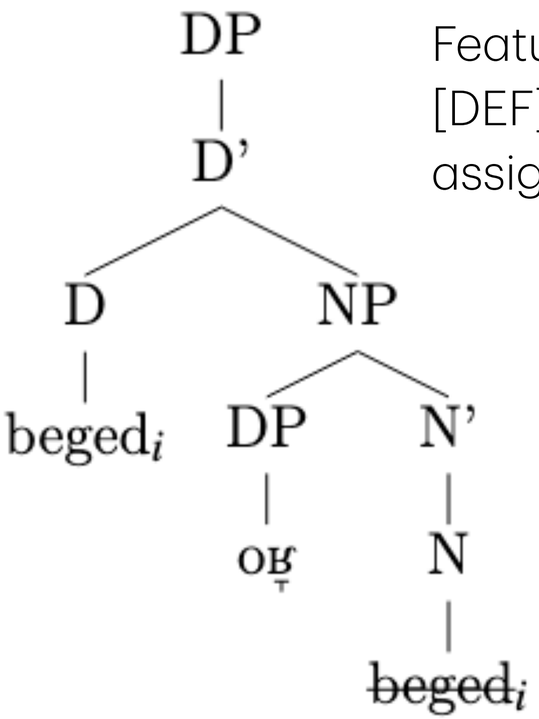
Cinque compounds



"The non-head is a modifier and thus an XP".

The syntactic structures (Borer, 1994; Danon 1998; Ritter 1988, 1991; Sichel 2002; Siloni 1997)

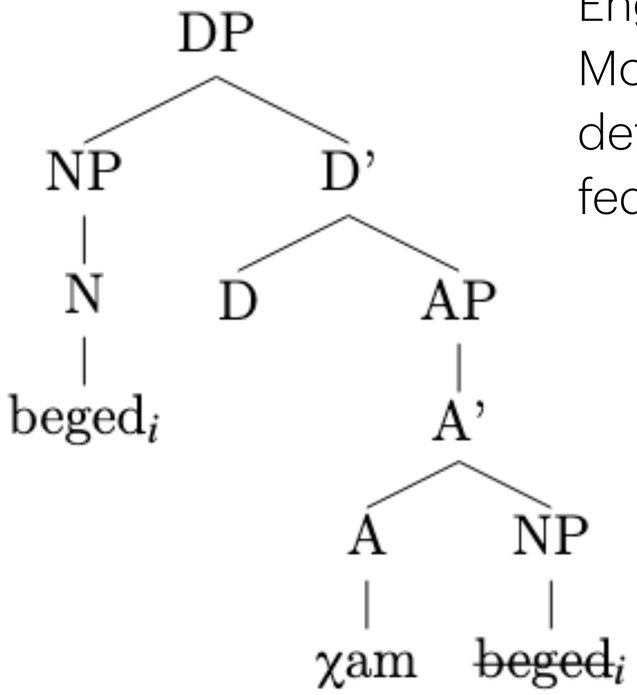
Construct states



Feature-driven movement: [DEF] + [GEN]. Non-head assigned θ + GEN.

suit leather
'leather suit'

N+A constructions



English mirror-image. Movement to check definiteness + agreement features on D.

suit warm
'warm clothing'

Match Theory (Selkirk, 2011)

- **Match Phrase:**

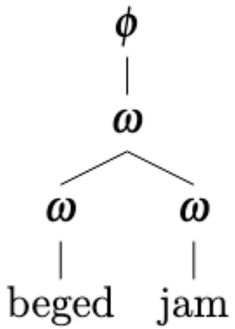
A phrase in syntactic constituent structure must be matched by a corresponding prosodic constituent, call it ϕ, in phonological representation.

- **Match Word:**

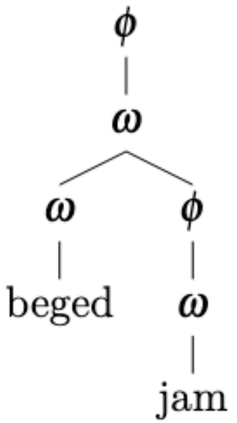
A word in syntactic constituent structure must be matched by a corresponding prosodic constituent, call it ω, in phonological representation.

Selkirk's predictions

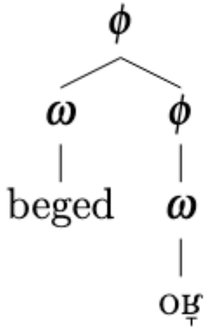
a. Classic compounds



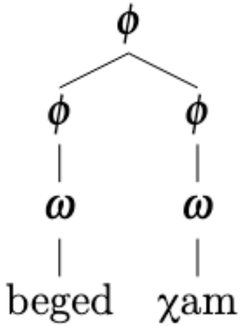
b. Cinque compounds



c. Construct states

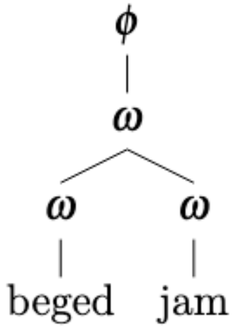


d. N+A constructions

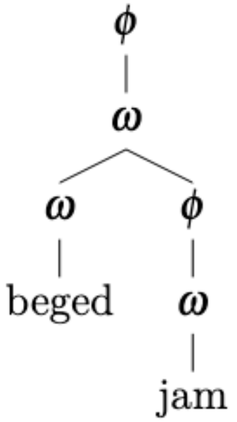


Selkirk's predictions - issues

a. Classic compounds



b. Cinque compounds



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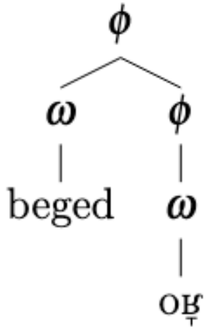

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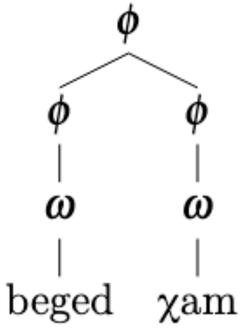


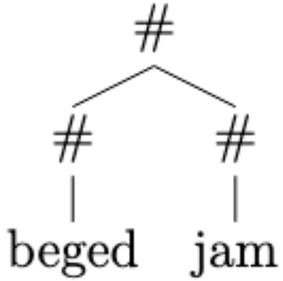
- No stress hierarchy
- Cinque compounds violate the Strict Layer Hypothesis.

Null Theory of Phrase Stress (Cinque, 1993)

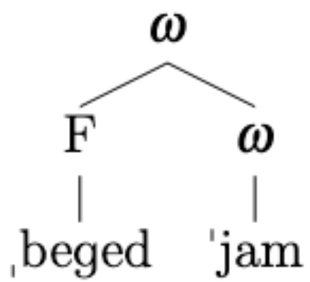
The stress prominence should fall on the main stress of the most deeply embedded constituent, assuming that constituents in a phrase are always asymmetric. In right-branching languages such as Hebrew, the stress prominence falls on the main stress of the rightmost constituent. Secondary stress should fall on the other syllable that bears primary stress prior to the formation of the entire phrase.

Cinque's predictions

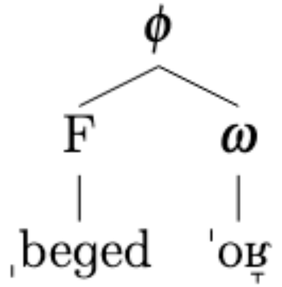
a. Classic compounds



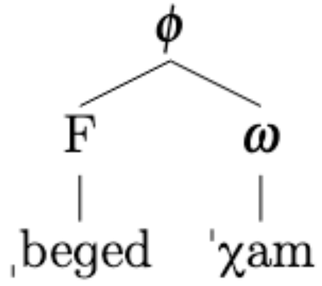
b. Cinque compounds



c. Construct states



d. N+A constructions



Cinque's predictions - issues

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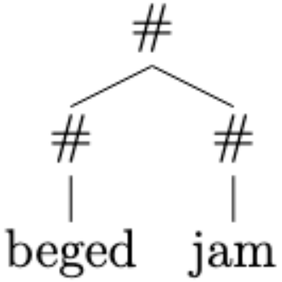

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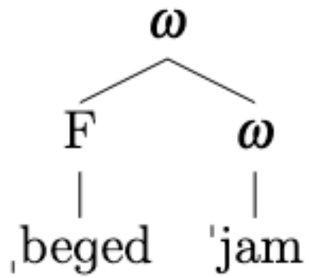
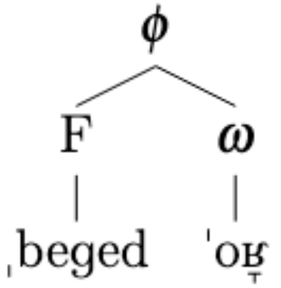
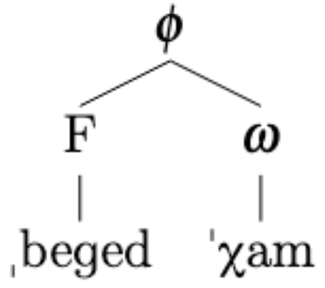


c. Construct states



d. N+A constructions

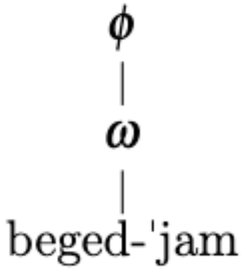


- No prediction for classic compounds

? Makes the same prediction for all construction types.

My predictions

a. Compounds



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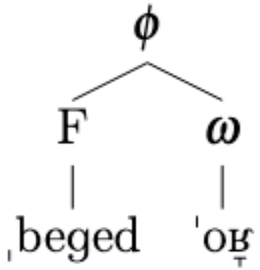
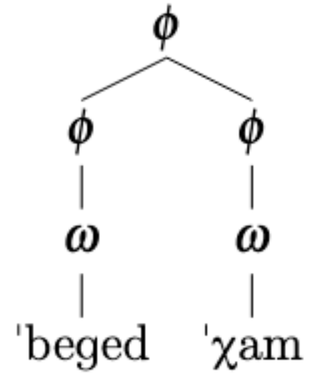


c. N+A constructions



EXPERIMENT

Method

Participants:

36 undergraduate students aged 21-30 (mean age = 24.2) participated in this study for credit. All were monolingual native speakers of Hebrew.

Materials: M-constructs vs. R-constructs (Borer, 2008)

- **M(odificational)-constructs:** the non-head is a modifier. Syntactically closer to a compounds (e.g., ‘glass table’, ‘wood floor’).

- **R(efetential)-constructs:** the non-head is a referential noun, the possessor of the head noun (e.g., ‘headmaster office’).

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Materials - the definiteness problem

Compounds:

orex din (`lawyer')

ha-orex din

orex **ha-**din ≠ orex din

M-constructs:

orex blog (`blog editor')

ha-orex blog

orex ha-blog ≠ orex blog

N+A constructions:

orex tov (`good editor')

ha-orex ha-tov

#**ha-**orex tov

*orex **ha-**tov

R-constructs:

xeder **ha-**menahel (`headmaster room')

#/? xeder menahel

Materials - construct state form

Compounds:

bet xol-im

house sick-PL

`hospital'

Construct states:

bet ec

house wood

`wood house'

N+A constructions:

bayit gadol

house big

`big house'

Materials

18 experimental items (6x3) and 24 fillers.

- All constructions must be indefinite
- Construct states whose head has a special construct form cannot be used
- The first element in every triplet must be identical
- Each triplet must contain the same number of syllables
- Construct states must be M-constructs, since R-construct are less natural when indefinite
- Compounds and construct states must be classified as such according to the diagnostics in the literature (Berman & Ravid, 1986; Borer, 2008)

Experimental items

Carrier sentence: Dana wrote _____ on the board in the classroom

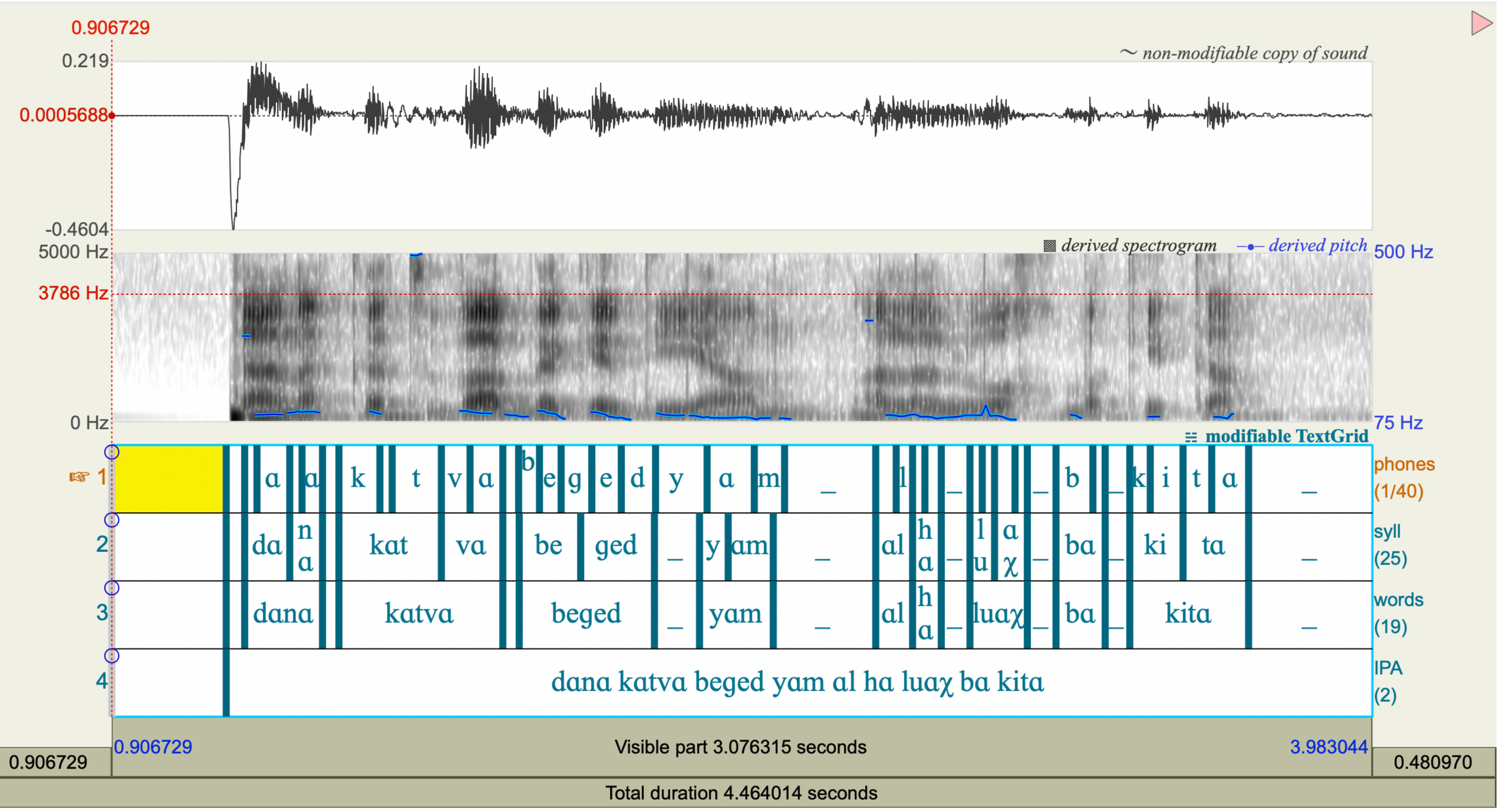
Compound	Construct state	N+A construction
oʁeχ din editor law ‘lawyer’	oʁeχ blog editor blog ‘blog editor’	oʁeχ tov editor good ‘good editor’
jom (h)uledet day birth ‘birthday’	jom moʁeʃet day heritage ‘heritage day’	jom sameaχ day happy ‘happy day’
matsav ʁuaχ state spirit ‘mood’	matsav laχats state pressure ‘stressful situation’	matsav stati state static ‘static state’
beged jam suit sea ‘swimsuit’	beged (ʔ)oʁ suit leather ‘leather suit’	beged χam suit hot ‘warm clothing’
kʁav maga fight touch ‘Krav Maga’ (Israeli martial art)	kʁav ʁovim fight rifle ‘gunfight’	kʁav kaʃe fight hard ‘hard fight’
masaχ (ʔ)ašan screen smoke ‘smoke screen’	masaχ maχʃev screen computer ‘computer screen’	masaχ ʃavuʁ screen broken ‘broken screen’

Filler items

Carrier sentence: Dana wrote _____ on the board in the classroom

jeled navon boy clever	jeled neχmad boy nice	jeled χaχam boy smart
tapuaχ jarok apple green	tapuaχ t͡sa(h)ov apple yellow	tapuaχ adom apple red
laleχet habaita go.INF home.to	laleχet leeχol go.INF eat.INF	laleχet liʃon go.INF sleep.INF
likfo͡ts la-maim jump,INF to-the-water	likfo͡ts ban͡dʒi jump.INF bungee	likfo͡ts gavoa jump.INF high
ledaber ba-avir speak.INF in.the-air	ledaber be-ʃeket speak.INF in-quiet	ledaber anglit speak.INF English
lir'ot kaful see-INF double	lir'ot koχavim watch.INF stars	lir'ot televizia watch.INF television

Method - data analysis



RESULTS: FIRST ELEMENT

Results - Duration

The first element of compounds was found to be the shortest. No significant difference between construct states and N+A constructions found.

	Estimate	Std. Error	t	*p*
(Intercept)	54.821	7.135	7.683	0.0611 .
ConditionCS	11.191	3.365	3.326	0.005 **
ConditionNA	7.422	3.365	2.206	0.0446 *

```
contrast estimate   SE df t.ratio p.value
NA  - CS    -3.77 3.36 14  -1.120  0.2815
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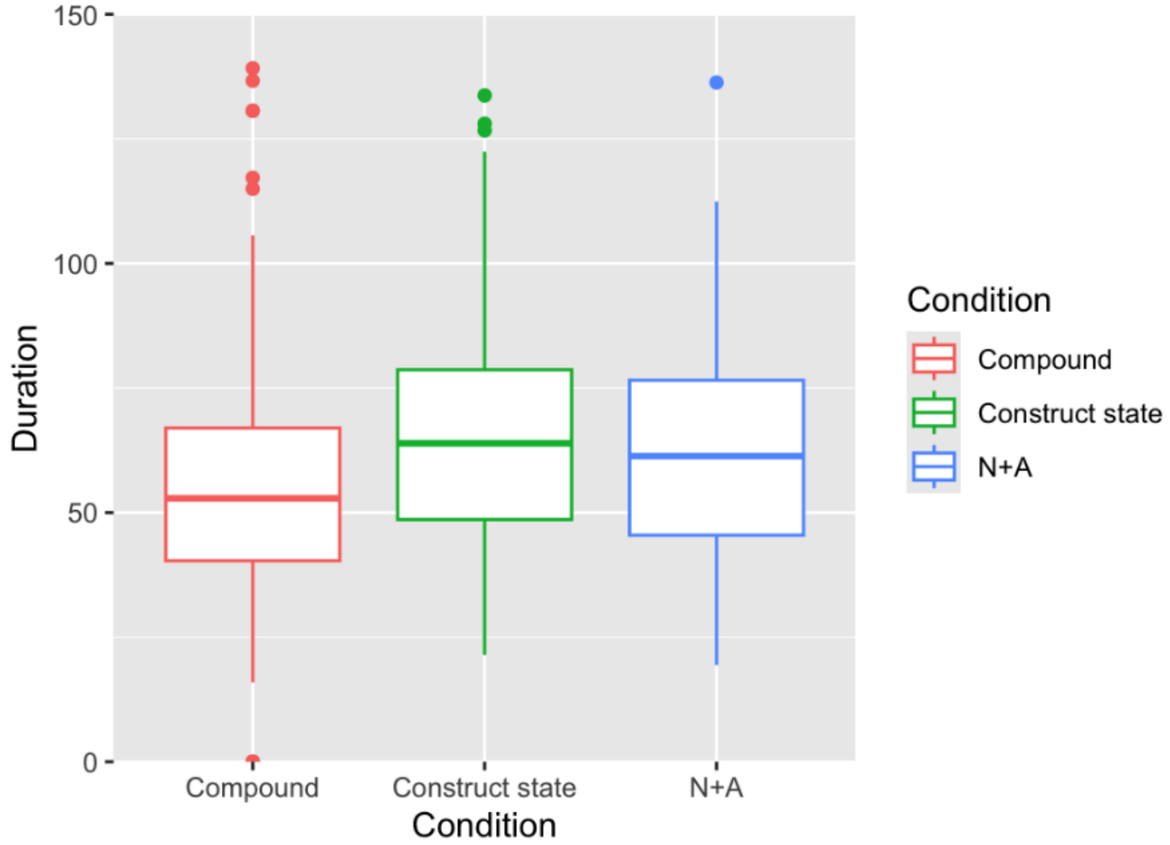
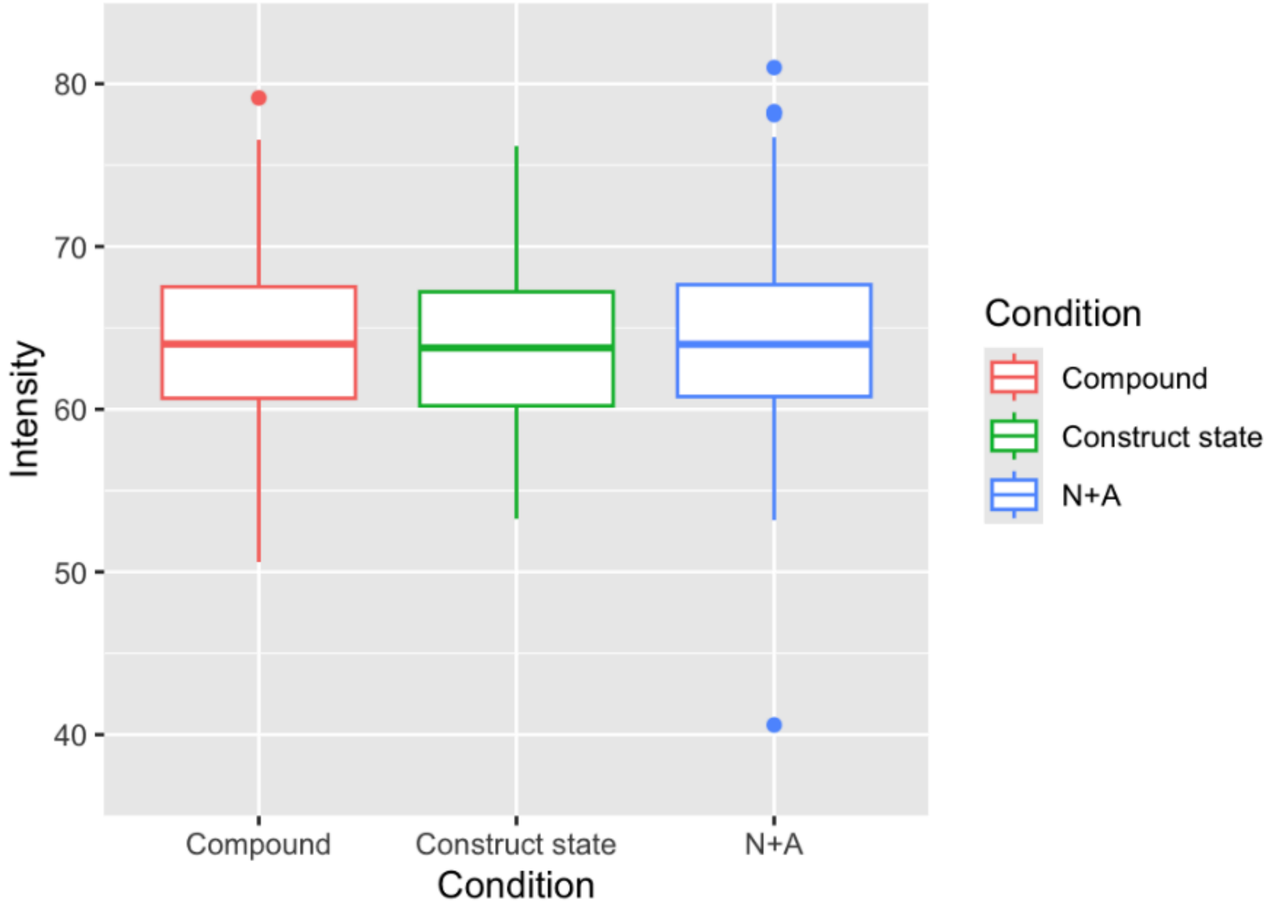


Results - Intensity

No significant differences

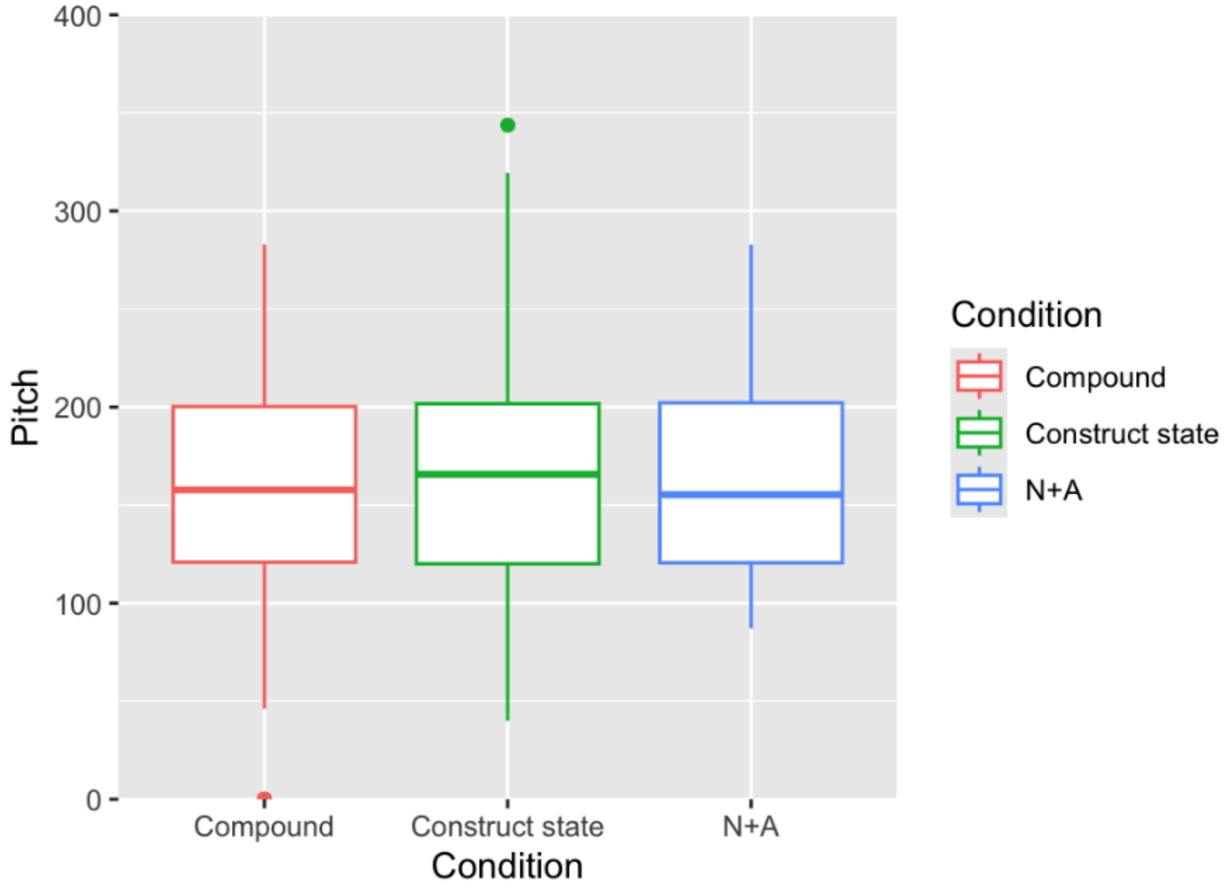
	Estimate	Std. Error	t	*p*
(Intercept)	64.588	0.79982	80.753	< 0.001 ***
ConditionCS	-0.10115	0.73341	-0.138	0.892269
ConditionNA	0.03135	0.73341	0.043	0.966505



Results - Pitch

No significant differences

	Estimate	Std. Error	t	*p*
(Intercept)	162.2178	3.3034	49.107	< 0.001 ***
ConditionCS	1.8536	4.6716	0.397	0.692
ConditionNA	0.6579	4.6716	0.141	0.888



Summary - First element results

- As already found in Cohen et al. (2018), duration seems to be the most reliable acoustic cue for stress in Hebrew.
- The first element of compounds was found to be the shortest. No significant difference between construct states and N+A constructions.
- No significant difference in intensity and pitch was found between the different constructions.

Research Questions

- Q1: Compounds, construct states and N+A constructions have different syntactic structure. Are the syntactic differences among these constructions reflected in different prosodic structures?
- Q2: Does Hebrew have secondary stress at the phrase level?
- Q3: Does frequency play a role in the prosodic structures both within and between these construction groups?
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Research Questions

- **Q1: Compounds, construct states and N+A constructions have different syntactic structure. Are the syntactic differences among these constructions reflected in different prosodic structures? - YES**
- Q2: Does Hebrew have secondary stress at the phrase level?
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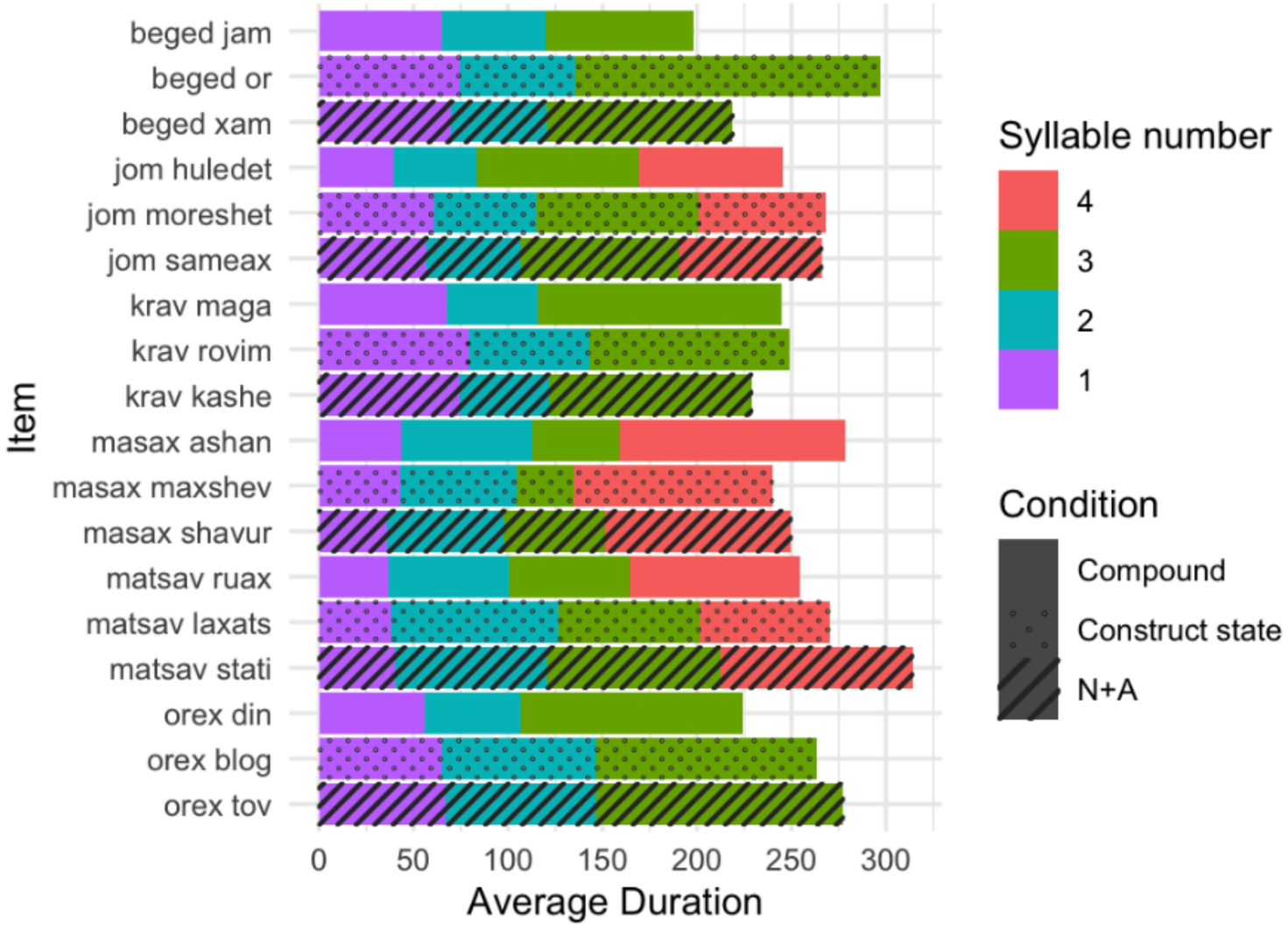
RESULTS: FULL CONSTRUCTION

Results - duration across items



Frequency (heTenTen)

Compound

CS

N+A

orex din	118706	kʁav kaʃe	1416	oʁeχ tov	112
jom (h)uledet	91607	masaχ (ʕ)ašan	895	beged χam	83
matsav ʁuaχ	21837	matsav stati	693	beged (ʕ)oʁ	50
beged jam	4645	jom sameaχ	654	jom moʁeʃet	33
kʁav maga	2087	matsav laχa͡ts	304	oʁeχ blog	19
masaχ maχʃev	1991	masaχ ʃavuʁ	240	kʁav ʁovim	2

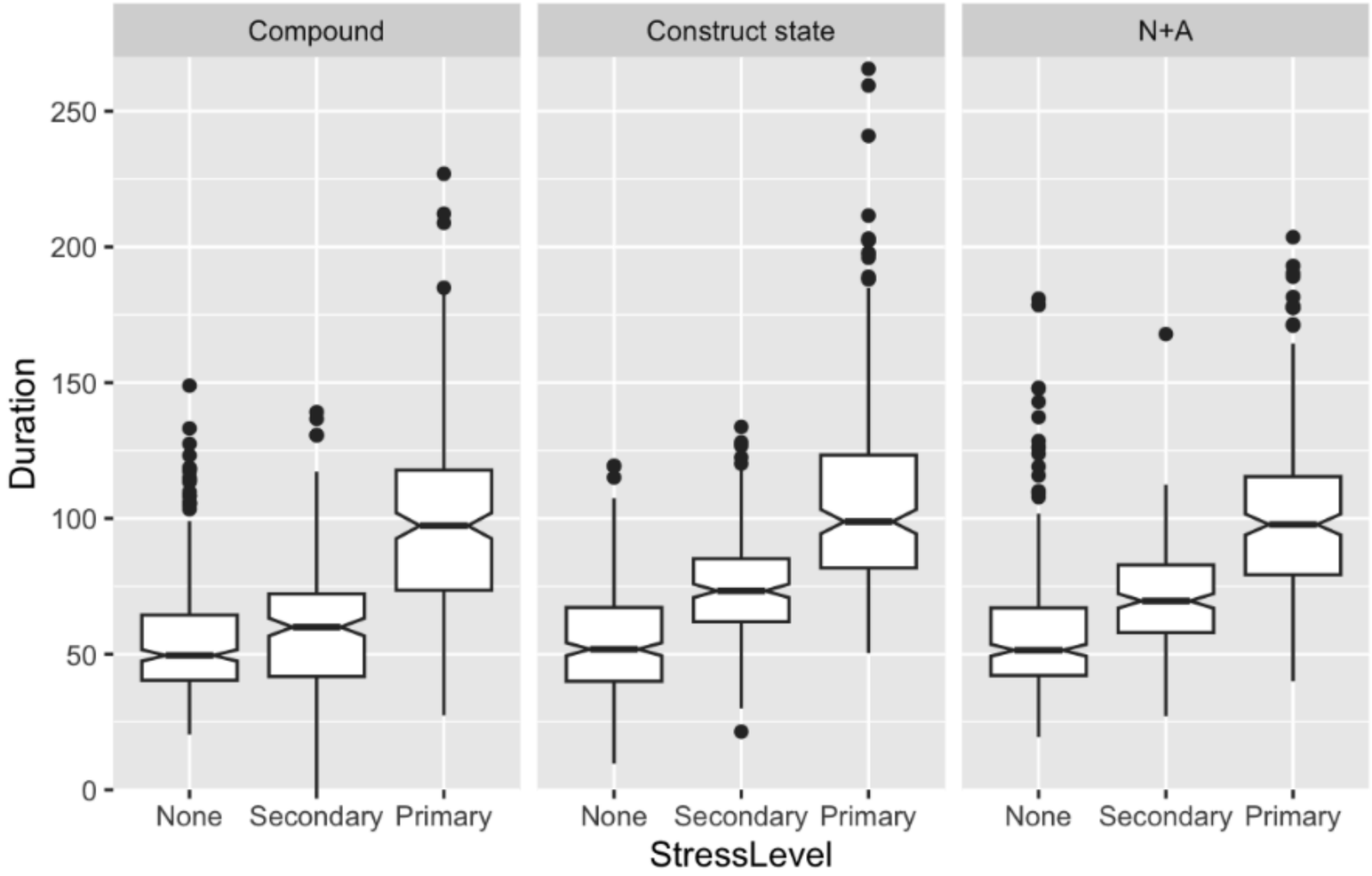
Results - GLMM

Reference levels: Stress Level = Secondary, Condition = Compound

	Estimate	Std. Error	t	*p*
(Intercept)	4.3991	0.24872	17.687	< 0.001 ***
StressLevelPrimary	0.32181	0.03681	8.743	< 0.001 ***
StressLevelNone	-0.19919	0.02598	-7.668	< 0.001 ***
ConditionCS	0.12727	0.09099	1.399	0.16189
ConditionNA	0.09624	0.07423	1.297	0.19477
log(Frequency)	-0.01506	0.01332	-1.131	0.25818
StressLevelPrimary:ConditionCS	-0.19143	0.03923	-4.879	< 0.001 ***
StressLevelNone:ConditionCS	-0.23483	0.03536	-6.641	< 0.001 ***
StressLevelPrimary:ConditionNA	-0.10203	0.03847	-2.653	0.00799 **
StressLevelNone:ConditionNA	-0.14818	0.03528	-4.2	< 0.001 ***

Significant main effect for Stress Level, no effect for Condition, significant interaction

Results - duration by stress level and condition



Results - post-hoc

- Significant difference between unstressed and secondarily stressed syllables within compounds ($p < 0.001$).
- No significant differences between secondary stress in compounds and secondary stress in construct states ($p = 0.286$) and in N+A constructions ($p = 0.28$).
- No significant difference between secondary stress in construct states and in N+A constructions ($p = 0.921$).

Secondary stress in compounds

Is this real and consistent secondary stress?

YES

Secondary stress in compounds is similar to secondary stress in construct states and N+A constructions

NO

Some items have secondary stress and some only primary

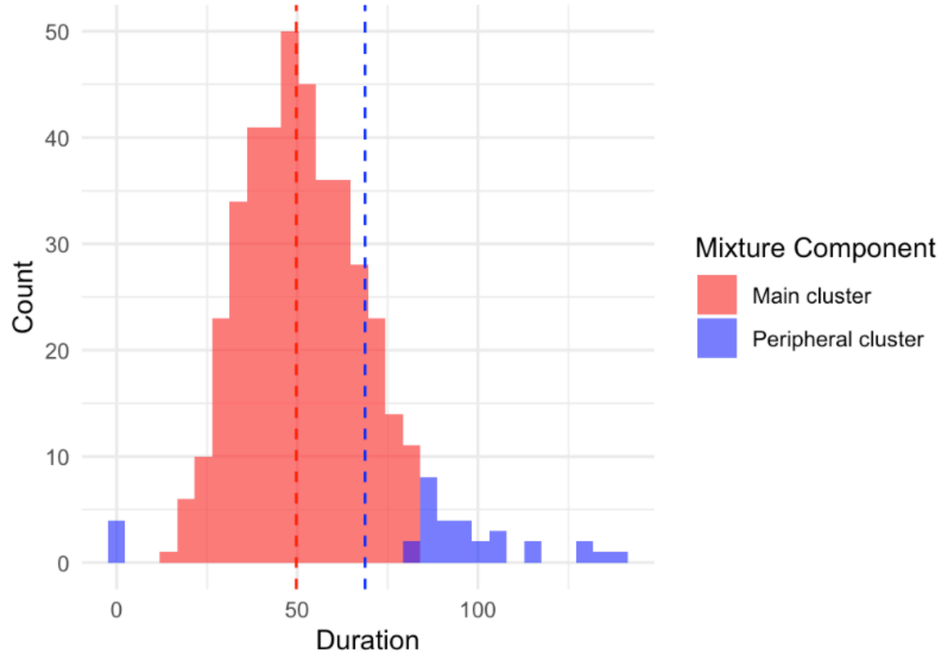
OR

For some participants there is secondary stress and for others only primary

Secondary stress in compounds

- Silverman's test on both raw durations (p = 0.414) and residuals from a mixed-effects model (p = 0.598) found no evidence for bimodality.

- A two-component mixture-model provided a significantly better fit than a single-component model (ΔAIC = 37.03; ΔBIC = 24.82). However, what the second cluster captured was a small number of outliers (33 observations out of 432).



Secondary stress in compounds

Is this real and consistent secondary stress?

YES

Secondary stress in compounds is similar to secondary stress in construct states and N+A constructions

Research Questions

- Q1: Compounds, construct states and N+A constructions have different syntactic structure. Are the syntactic differences among these constructions reflected in different prosodic structures? - YES
- **Q2: Does Hebrew have secondary stress at the phrase level?**
- **Q3: Does frequency play a role in the prosodic structures both within and between these construction groups?**
- Q4: Are the attested prosodic structures predicted by theories of syntax-prosody correspondence?

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ANALYSIS

Summary

- All constructions exhibit a similar stress pattern: the stressed syllable of the first element bears secondary stress and the stressed syllable of the second element bears the primary stress.

- The first element in compounds was found to be significantly the shortest - syntactic differences influence stress pattern and prosodic structures.

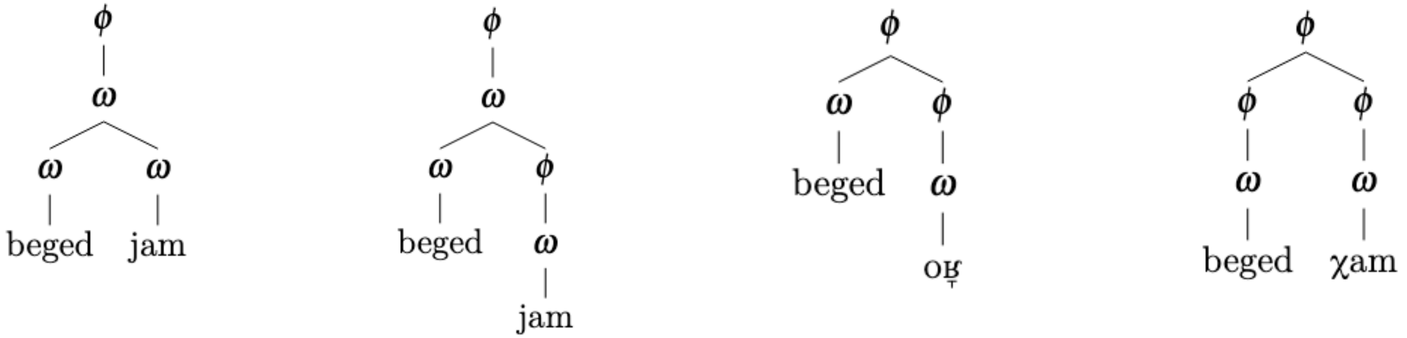
Proposal

- We need to combine Selkirk's Match Theory and Cinque's Null Theory of Phrase Stress, with a slight modification.

Selkirk's and Cinque's predictions

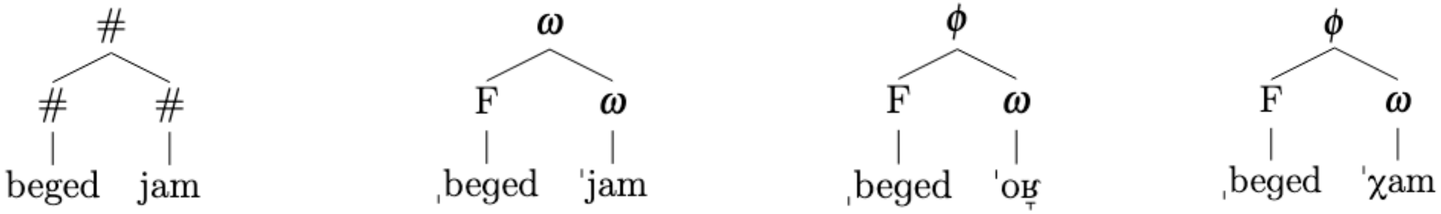
Selkirk = adequate syntax-to-prosody mapping

a. Classic compounds b. Cinque compounds c. Construct states d. N+A constructions



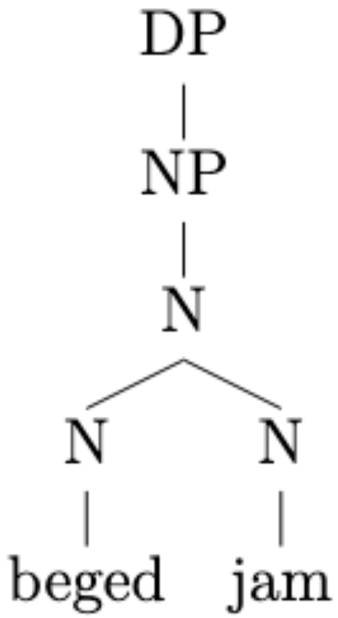
Cinque = captures the asymmetry

a. Classic compounds b. Cinque compounds c. Construct states d. N+A constructions

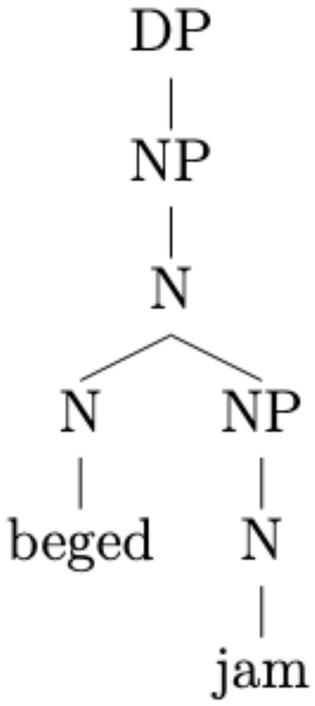


Slight modification…

Classic compounds

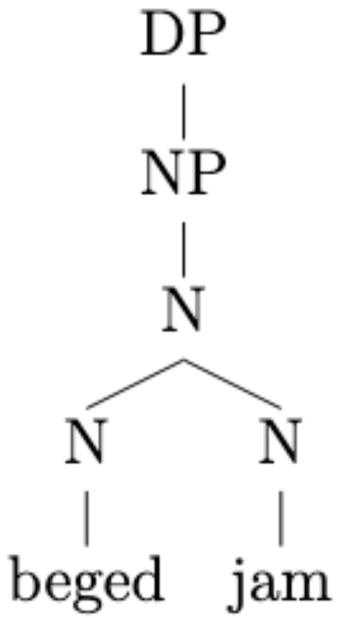


Cinque compounds

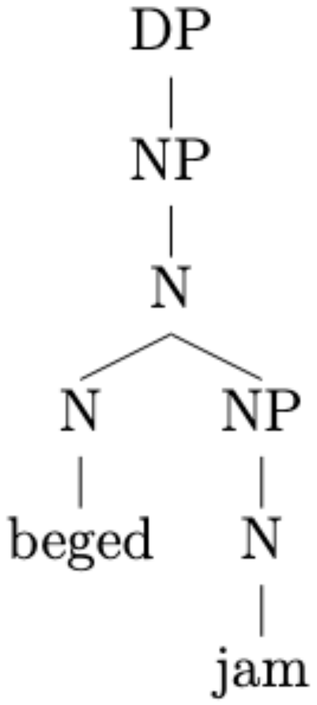


Slight modification…

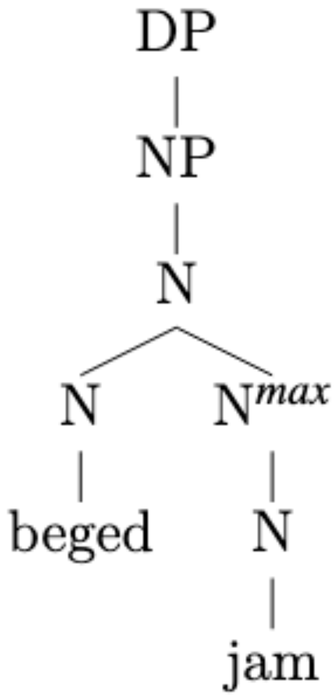
Classic compounds



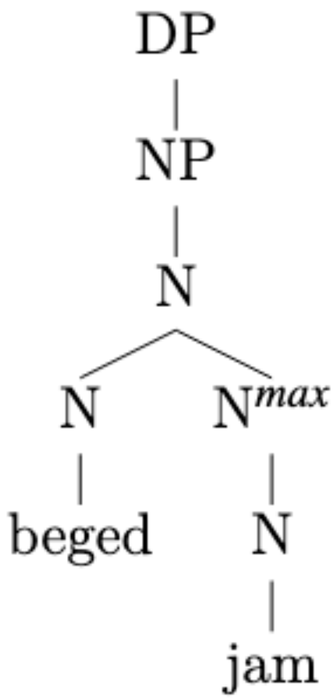
Cinque compounds

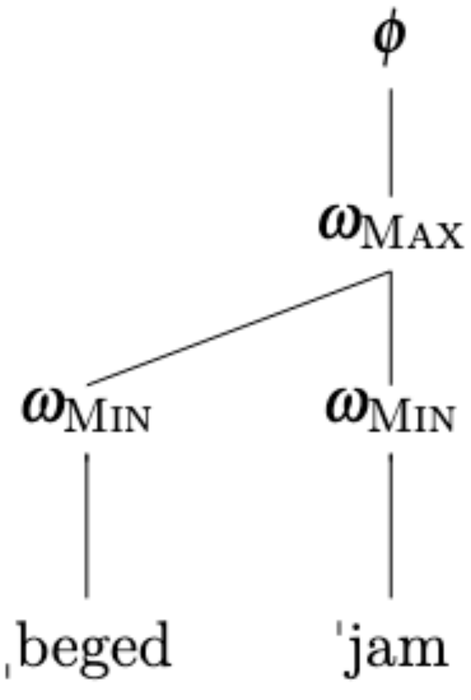


My compounds

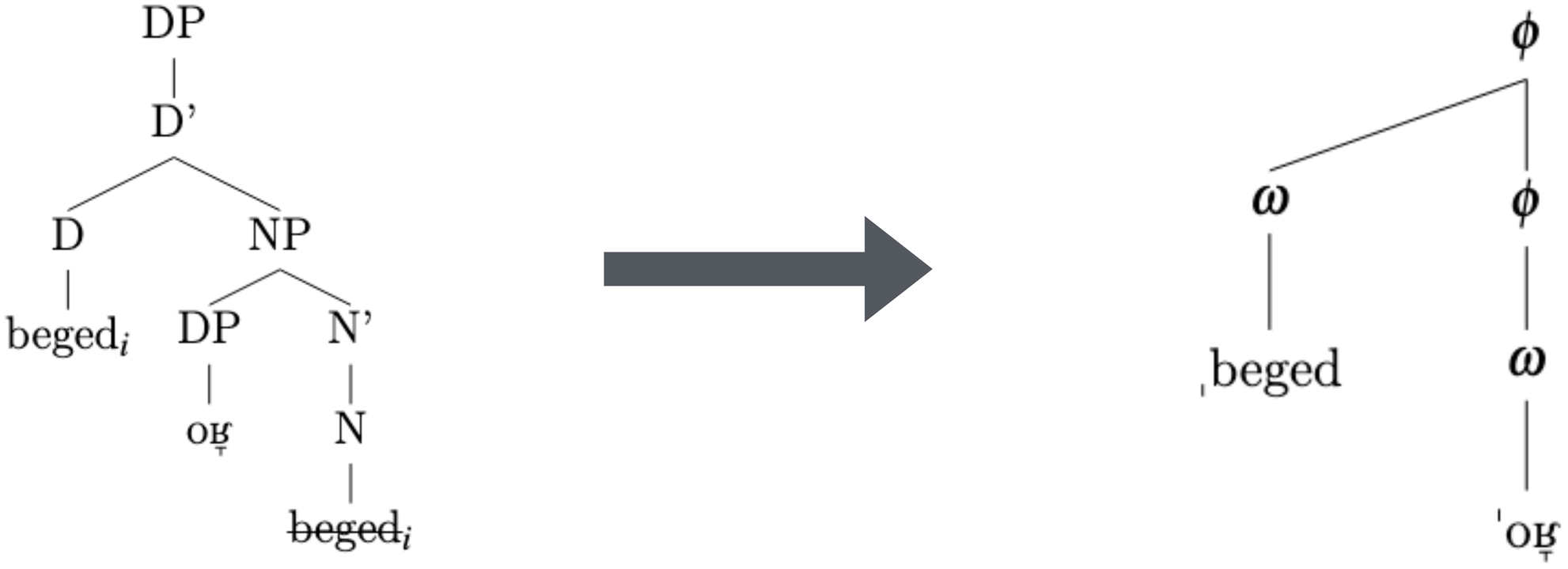


Proposal - compounds

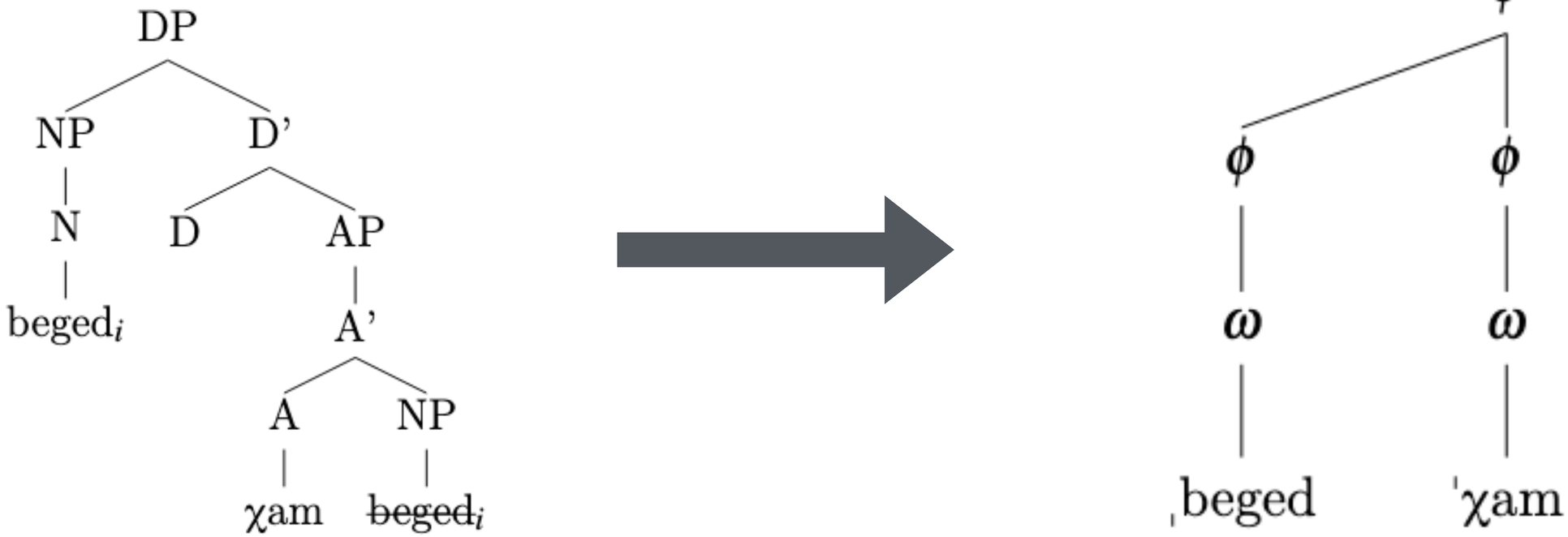




Proposal - construct states

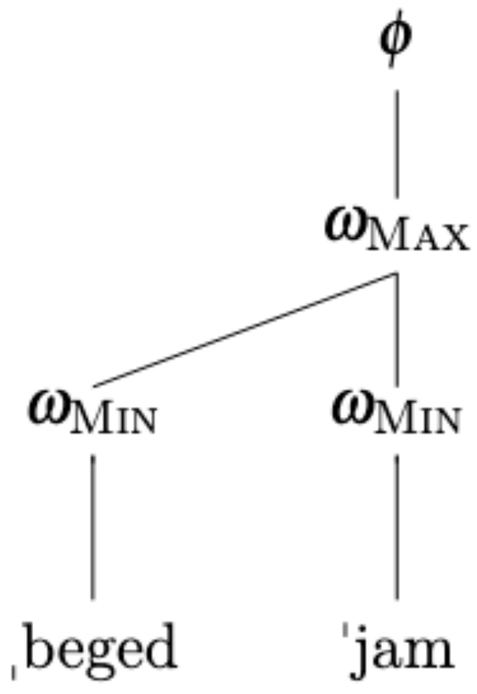


Proposal - N+A constructions

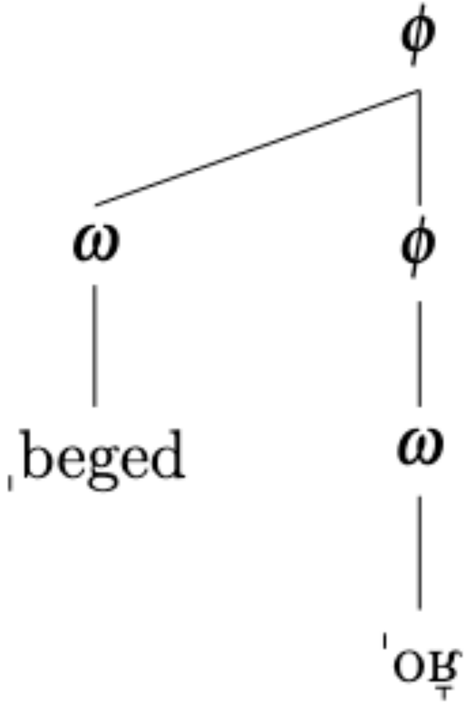


Summary of prosodic structures

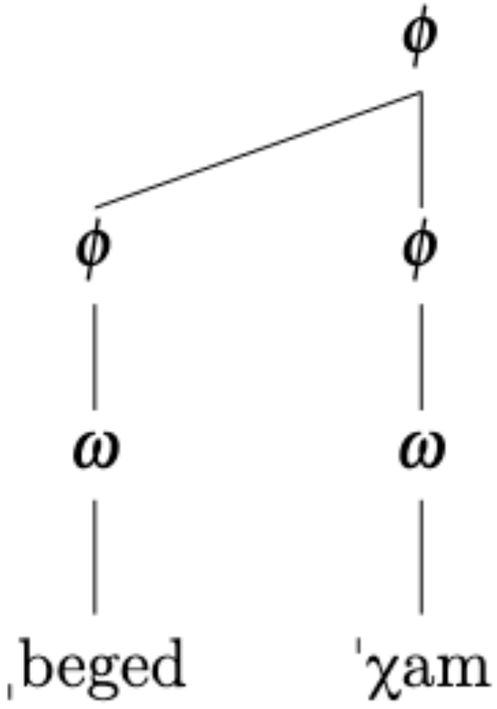
Compounds



Construct states



N+A constructions



OT analysis

1. Match(α, π): The left and right edges of a constituent of type α in the input syntactic representation must correspond to the left and right edges of a constituent of type π in the output phonological representation.

2. AlignR(ϕ ,ωs): The right edge of the phonological phrase must correspond to the right edge of the prosodic word bearing primary stress.

$[_{NP}[_N[_N$ 'beged] $[_N$ 'jam]]]		MATCH(α,π)	ALIGNR(ϕ,ω_s)
a.	☞ (ϕ (ω (ω ˌbeged) (ω 'jam)))		
b.	(ϕ (ω (ω 'beged) (ω ˌjam)))		*!*
c.	(ϕ (ω (ω 'beged) (ω 'jam)))		*!
d.	(ϕ (ω ˌbeged) (ω 'jam)))	*!	
e.	(ϕ (ω (ˌbeged) (ω 'jam)))	*!	
f.	(ϕ (ˌbeged) (ω 'jam))	*!*	

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$[_{DP}[_{D}$ 'beged] $[_{NP}[_{DP}[_{N}$ 'oʁ̞]]]	MATCH(α,π)	ALIGNR(ϕ,ω_s)
a. ☞ (ϕ (ω ˌbeged) (ϕ (ω 'oʁ̞)))		
b. (ϕ (ω 'beged) (ϕ (ω 'oʁ̞)))		*!
c. (ϕ (ˌbeged) (ϕ (ω 'oʁ̞)))	*!	

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$[_{DP}[_{NP}[_{N}$ 'beged]] $[_{AP}[_{A}$ 'χam]]]	MATCH(α, π)	ALIGNR(ϕ, ω_s)
a. ☞ (ϕ (ϕ (ω ˌbeged)) (ϕ (ω 'xam)))		
b. (ϕ (ϕ (ω 'beged)) (ϕ (ω 'xam)))		*!
c. (ϕ (ω 'beged) (ϕ (ω 'xam)))	*!	

CONCLUSION

Conclusion

- While Hebrew does not exhibit secondary stress at the minimal prosodic word level, it was found to emerge at the maximal prosodic word and the phrase levels.
- The three phrase types examined – compounds, construct states and N+A constructions – all exhibited a similar pattern: primary stress on the stressed syllable of the second element and secondary stress on the stressed syllable of the first element.
- The first element of compounds was found to be the shortest, pointing at the influence of the syntax on the prosodic structure.
- Current syntax-prosody correspondence theories do not fully account for the attested pattern and must be combined in order to do so.
- Frequency does not seem to play a role in stress pattern.

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