

Precedence theory, root and template morphology, priming effects and the structure of the lexicon

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1.0 Precedence Based Phonology

- The fundamental proposal in Raimy (1999a, 2000ab) is that phonological representations contain explicit precedence relations which are manipulable by both the morphology and phonology
- Analyses adopting this representational enrichment are generally referred to as ‘precedence based phonology’ (henceforth PBP)
- There is a misconception that PBP is only relevant to reduplication and thus contains ‘reduplication specific mechanisms’ (Downing 2001)
- Existing work has demonstrated the utility of PBP analyses in the following:
 - reduplication (see references for a full list)
 - metathesis (Halle 2001)
 - ludlings (Nevins and Vaux 2003, Idsardi and Raimy 2005, Nevins 2007)
 - syllable structure (Idsardi and Raimy 2005, Raimy to appear)
 - poetic devices: rhyme and alliteration (Idsardi and Raimy 2005)
 - infixation (Raimy 1999a, 2000a, Guimaraes and Nevins 2006)
 - acquisition (Iba and Nevins 2004, Chinn and Raimy 2006)
- Goals of this paper are:
 - unification of concatenative and non-concatenative morphology via PBP
 - analysis of Modern Standard Arabic (MSA) Verbal morphology to demonstrate this unification
 - a proposal on the structure of the lexicon based on PBP
 - a sketch of how a PBP lexicon explains psycholinguistic findings

2.0 Modern Standard Arabic (MSA) Verbal Morphology

- (1) presents the classic paradigm of MSA verbal morphology for trilateral roots

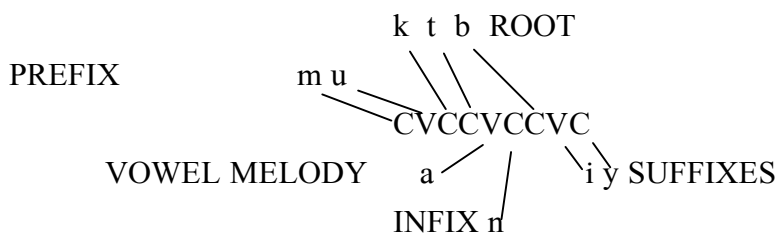
(1) Table I (McCarthy 1979:244)

Binyan	Perfective	Perfective	Imperfective	Imperfective	Active	Passive
	Active	Passive	Active	Passive	Participle	Participle
I	katab	kutib	<u>aktub</u>	<u>uktab</u>	kaatib	<u>maktuub</u>
II	kattab	kuttib	<u>ukattib</u>	<u>ukattab</u>	<u>mukattib</u>	<u>mukattab</u>
III	kaatab	kuutib	<u>ukaatib</u>	<u>ukaatab</u>	<u>mukaatib</u>	<u>mukaatab</u>
IV	<u>ʔaktab</u>	<u>ʔuktib</u>	<u>uʔaktib</u>	<u>uʔaktab</u>	<u>muʔaktib</u>	<u>muʔaktab</u>
V	<u>takattab</u>	<u>tukuttib</u>	<u>atakattab</u>	<u>utakattab</u>	<u>mutakattib</u>	<u>mutakattab</u>
VI	<u>takaatab</u>	<u>tukuutib</u>	<u>atakaatab</u>	<u>utakaatab</u>	<u>mutakaatib</u>	<u>mutakaatab</u>
VII	<u>nkatab</u>	<u>nkutib</u>	<u>ankatib</u>	<u>unkatab</u>	<u>munkatib</u>	<u>munkatab</u>
VIII	ktatab	ktutib	<u>aktatib</u>	<u>uktatab</u>	<u>muktatib</u>	<u>muktatab</u>
IX	ktabab		<u>aktabib</u>		<u>muktabib</u>	
X	<u>staktab</u>	<u>stuktib</u>	<u>astaktib</u>	<u>ustaktab</u>	<u>mustaktib</u>	<u>mustaktab</u>
XI	ktaabab		<u>aktaabib</u>		<u>muktaabib</u>	
XII	ktawtab		<u>aktawtib</u>		<u>muktawtib</u>	
XIII	ktawwab		<u>aktawwib</u>		<u>muktawwib</u>	
XIV	ktanbab		<u>aktanbib</u>		<u>muktanbib</u>	
XV	ktanbay		<u>aktanbiy</u>		<u>muktanbiy</u>	

- The treatment of the patterns in (1) based on McCarthy (1979, 1981) is that MSA is morphologically analyzed into 3 pieces:
 - the root
 - the templates (including prefixes and infixes but not agreement suffixes)
 - the vowel melody

(2) Decomposition of MSA Verbs

XV Active Participle *muktanbiy*



- One aspect of MSA verbal morphology that should be noted is the large amount of prefixation and suffixation present (all affixes have been underlined)
- Prefixation and suffixation is common to all languages and thus trivial for everyone

- It is the intercalation of the vowels into the roots which is interesting aspect of root and template morphology
- (2) presents the core intercalation patterns of vowels and infixes; prefixes and suffixes have been eliminated with the vowel melody indicating Active Participle

(2) Core intercalation patterns in MSA verbal morphology

Binyan(im)	Word Pattern	Affixes
IV, X	ktib	Base Vowel
VII	katib	Base Vowel, First Vowel
II, V	kattib	Base Vowel, First Vowel, C Gemination
III, VI	kaatib	Base Vowel, First Vowel, V Gemination
VIII	ktatib	Base Vowel, First Vowel, /t/ Infixation
XII	ktawtib	Base Vowel, First Vowel, /t/ Infixation, C Infixation
IX	ktabib	Base Vowel, Final Reduplication
XI	ktaabib	Base Vowel, Final Reduplication, V Gemination
XV	ktaab	Base Vowel, C Infixation
XIV	ktaabib	Base Vowel, C Infixation, Final Reduplication
XIII	ktawwib	Base Vowel, C Infixation, Base Vowel (2nd), C Gemination

- Binyan I has been eliminated from (2) because it does not have a uniform ‘template’ across the different conjunctions within the Binyan
- Binyanim II-XV all have a uniform ‘template’ with only vowel melody, prefixation and suffixation marking the different conjugations within the particular Binyan
- In order to derive the all of the templates (word patterns) in (2) we only need 7 different affixes
- Each affix will be introduced in the following examples by defining what Anchor Points (Raimy 2005) are required to describe the phonological material that is added
- Result is that ‘template’ and ‘word pattern’ are epiphenomenal and derived from these more explicit affixations

3.0 Deriving the Binyanim from affixation in PBP

- This section demonstrates how the templates/word patterns are derived by the addition of phonological material described by PBP

3.2 Binyan VII

- Binyan VII contains the Base Vowel (3) and the First Vowel affix described in (5) along with the prefix [mun] to indicate Active Participle
- Order of presentation in the first statement, i.e. BV (3) before FV(5), is the order of spell-out and this convention will be followed in the remainder of the talk

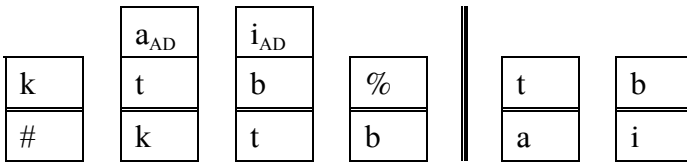
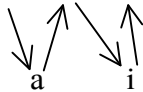
(5) First Vowel

‘/a/ follows the first segment and precedes the segment after the first segment’

{F(irst)Seg} → V → {FSeg_}

(6) Derivation for Binyan VII

→ k → t → b → % linearizes to [katib] >>> VII [munkatib]



- The difference in Binyan I forms are dependent on unpredictable vowel melody of the Base Vowel and whether the First Vowel is spelled out:
 - First Vowel appears in both Perfectives and the Active Participle
 - First Vowel does not appear in both Imperfectives and the Passive Participle

3.3 Binyanim II and V

- Binyanim II and V contain the Base Vowel (3) , First Vowel (5) and the C Gemination affix described in (7)

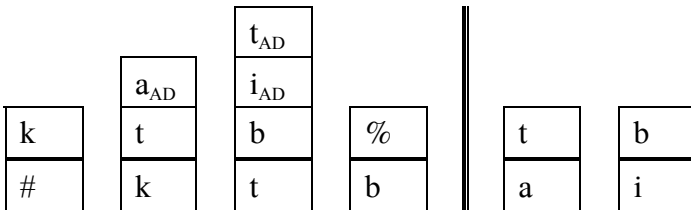
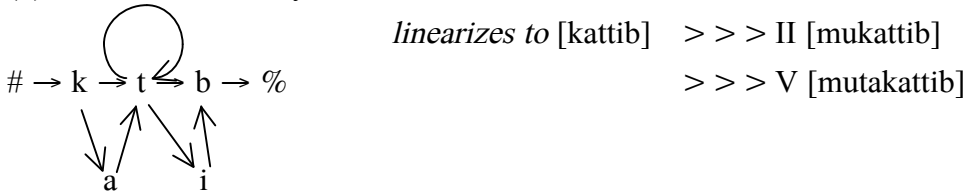
(7) C Gemination

‘the segment after the first vowel follows the segment after the first vowel’

{FVow_} → {FVow_}

- Binyan II has a complex prefix [mu] and Binyan V has the complex prefix [muta]

(8) Derivation for Binyanim II and V



3.4 Binyanim III and VI

- Binyanim III and VI contain the Base Vowel (3), First Vowel (5) and the V Gemination affix in (9)

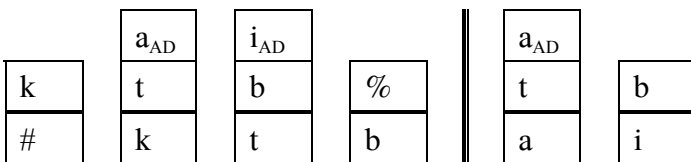
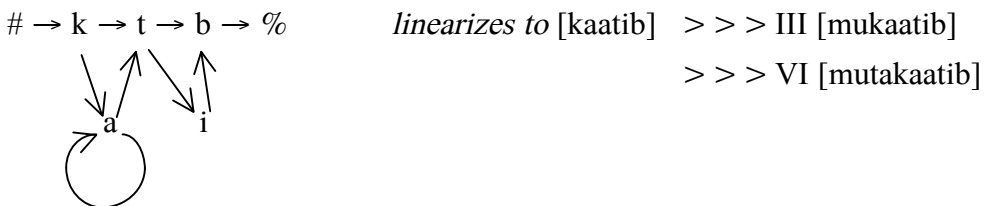
(9) V Gemination

‘the first vowel precedes the first vowel’

{FVow} → {FVow}

- Note the derivational ordering of the spell-out of V Gemination and First Vowel; First Vowel must have been spelled-out first, otherwise the /i/ in (10) would be geminated
- Binyan III also has the complex prefix [mu] while Binyan VI has [muta]

(10) Derivation for Binyanim III and VI



- V Gemination occurs in Binyan I for both types of Participles

3.5 Binyan VIII

- Binyan VIII contains the Base Vowel (3), First Vowel (5) and the /t/ Infix affix in (11)

(11) /t/ Infix

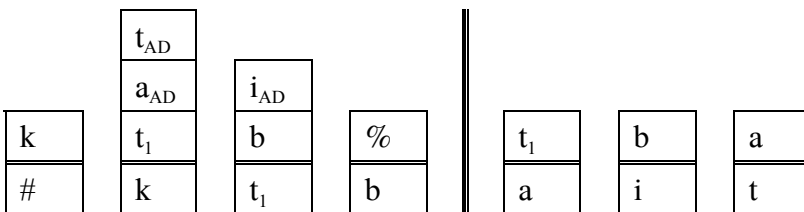
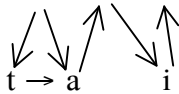
‘/t/ follows the first segment and precedes the segment after the first segment’

{FSeg} → t → {FSeg_}

- Note that PBP allows for direct infixation so McCarthy’s (1979, 1981) VIII Binyan Flop Rule is unnecessary
- Binyan VIII also has the complex prefix [mu] in the Active Perfective

(12) Derivation for Binyan VIII

→ k → t → b → % linearizes to [k_tatib] > > > VIII [muktatib]



3.6 Binyan XII

- Binyan XII contains the Base Vowel (3), First Vowel (5), /t/ Infix (11) and the C Infix affix in (13)
- The C Infix is /w/ in Binyanim XII and XIII and /n/ in Binyanim XIV and XV

(13) C Infix

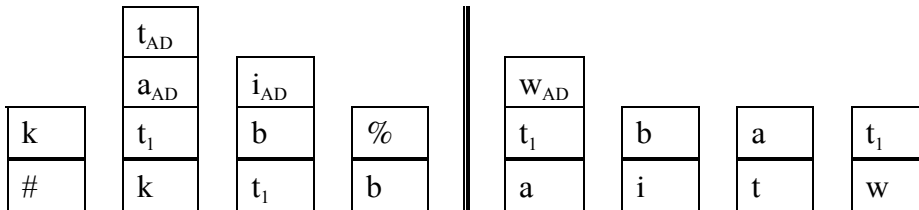
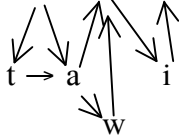
‘/w/ or /n/ follows the first vowel and precedes the segment after the first vowel’

{FVow} → C → {FVow_}

- Binyan XII also has the complex prefix [mu] and is considered “extremely rare” (McCarthy 1979:241) along with the other Binyanim XI-XV

(14) Derivation for Binyan XII

→ k → t → b → % *linearizes as* [ktawtib] > > > XII [muktawtib]



3.7 Binyan IX

- Binyan IX shows the Base Vowel (which appears as /a/ instead of /i/ in this Binyan) (3) and the Final Reduplication affix in (15) along with the complex prefix [mu]

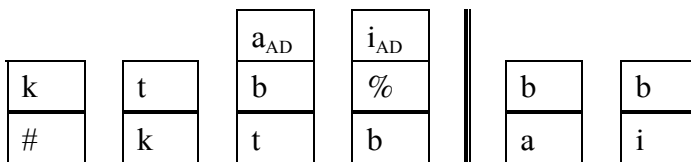
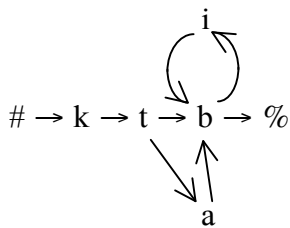
(15) Final Reduplication

'/i/ precedes the last segment and follows the last segment'

{LSeg} → i → {LSeg}

(16) Derivation for Binyan IX

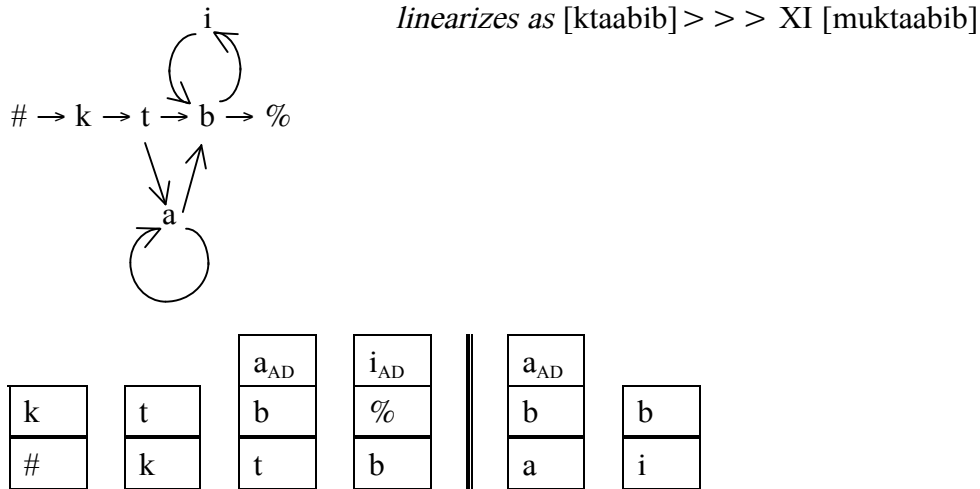
→ k → t → b → % *linearizes as* [ktabib] > > > IX [muktabib]



3.8 Binyan XI

- Binyan XI contains Base Vowel (specified as /a/ as in previous example) (3), V Gemination (9) and Final Reduplication (15) with the complex prefix [mu]

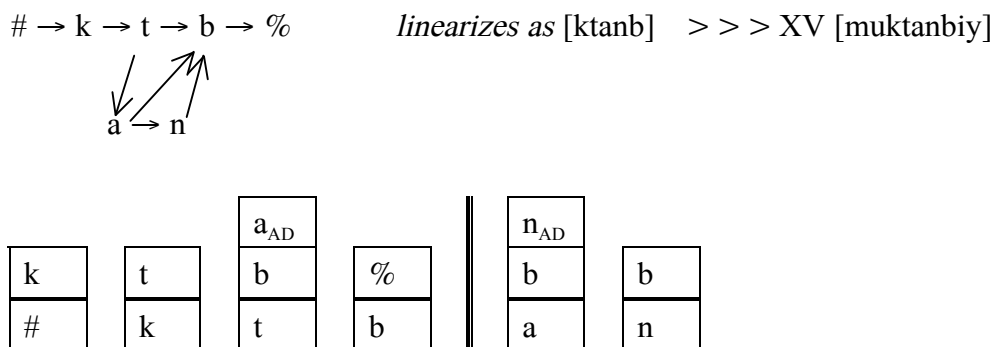
(17) Derivation of Binyan XI



3.9 Binyan XV

- Binyan XV shows the spell-out of Base Vowel (/a/ here) (3) and C Infix (13) specified for /n/ along with the complex prefix [mu] and complex suffix [iy]

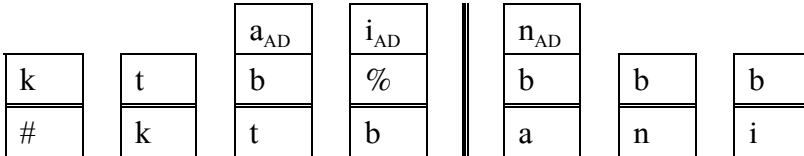
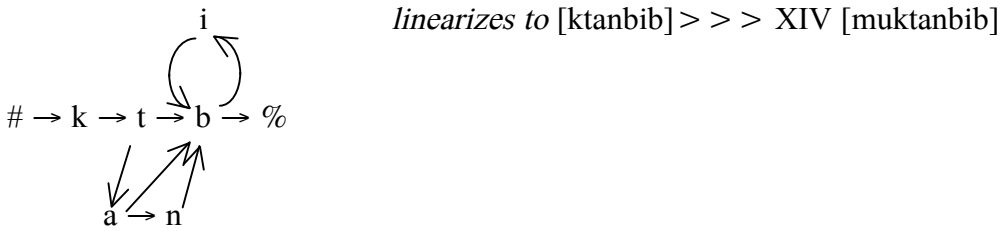
(18) Derivation for Binyan XV



3.10 Binyan XIV

- Binyan XIV shows the spell-out of Base Vowel (/a/ in this case) (3), C Infix (13) specified for /n/ and Final Reduplication (15) along with the complex prefix [mu]

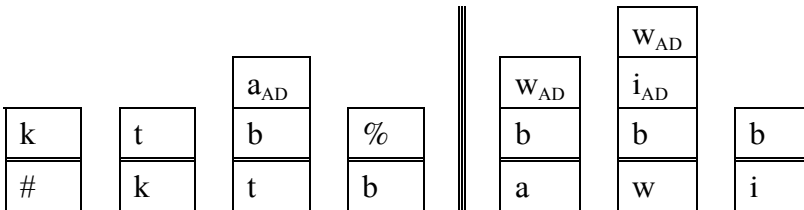
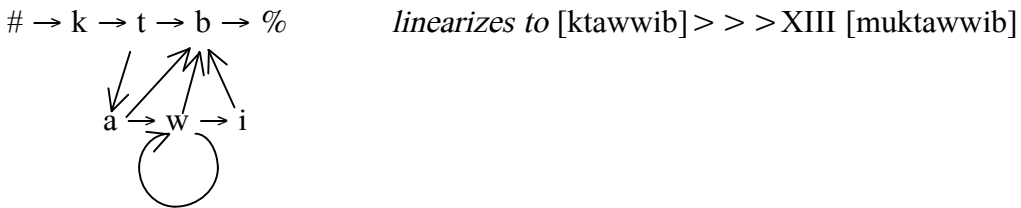
(19) Derivation for Binyan XIV



3.11 Binyan XIII

- Binyan XIII shows the spell-out of Base Vowel (/a/ in this case) (3), C Infix (13) specified for /n/, another spell out of Base Vowel (3) and C Gemination (7) along with the complex prefix [mu]

(20) Derivation for Binyan XIII



3.12 Summary of the pieces of MSA verbal morphology

- (21) presents a summary of all of the different phonological pieces required to generate the surface patterns of MSA Verbal Morphology

(21) Verbal Morphology in MSA

Affix	Phonological Content	Appears in Binyanim
Base Vowel (3)	{_LSeg} → V → {LSeg}	All
First Vowel (5)	{FSeg} → V → {FSeg_}	II, III, V, VI, VII, VIII, XII
C Gemination (7)	{FVow_} → {FVow_}	II, V, XIII
V Gemination (9)	{FVow} → {FVow}	III, VI, XI
/t/ Infix (11)	{FSeg} → t → {FSeg_}	VIII, XII
C Infix (13)	{FVow} → C → {FVow_}	XII, XIII, XIV, XV
Final Reduplication (15)	{LSeg} → V → {LSeg}	IX, XI, XIV

- The only Anchor Points that are required are: First Segment, Last Segment, After First Segment, Before Last Segment, First Vowel, After First Vowel
- Reanalysis of McCarthy (1979, 1981) *prosodic templates* in terms of the chart in (21) produces (22)
- McCarthy's *prosodic templates* have vowels left blank, affixal consonants filled in, some prefixes omitted and any additional processes listed

(22) A Precedence Based Theory of Templates

Binyan	McCarthy's Template	Precedence Based Template
II	CVCCVC <i>2nd, 5th Binyanim Erasure</i>	Base Vowel, First Vowel, C Gemination
III	CVVCVC	Base Vowel, First Vowel, V Gemination
IV	?VCCVC	Base Vowel
V	tVCVCCVC <i>2nd, 5th Binyanim Erasure</i>	Base Vowel, First Vowel, C Gemination
VI	tVCVVVCVC	Base Vowel, First Vowel, V Gemination
VII	nCVCVC	Base Vowel, First Vowel
VIII	tCVCVC <i>Eighth Binyan Flop</i>	Base Vowel, First Vowel, /t/ Infixation
IX	CCVCVC	Base Vowel, Final Reduplication
X	stVCCVC	Base Vowel
XI	CCVVCVC	Base Vowel, Final Reduplication, V Gemination
XII	CCVwCVC <i>2nd, 5th Binyanim Erasure</i>	Base Vowel, First Vowel, /t/ Infixation, C Infix
XIII	CCVwCVC <i>2nd, 5th Binyanim Erasure</i>	Base Vowel, C Infix, Base Vowel (2nd), C Gemination
XIV	CCVnCVC	Base Vowel, C Infix, Final Reduplication
XV	CCVnCVy	Base Vowel, C Infix

4.0 A PBP as a model of the lexicon

4.1 A very simple sketch of a PBP lexicon

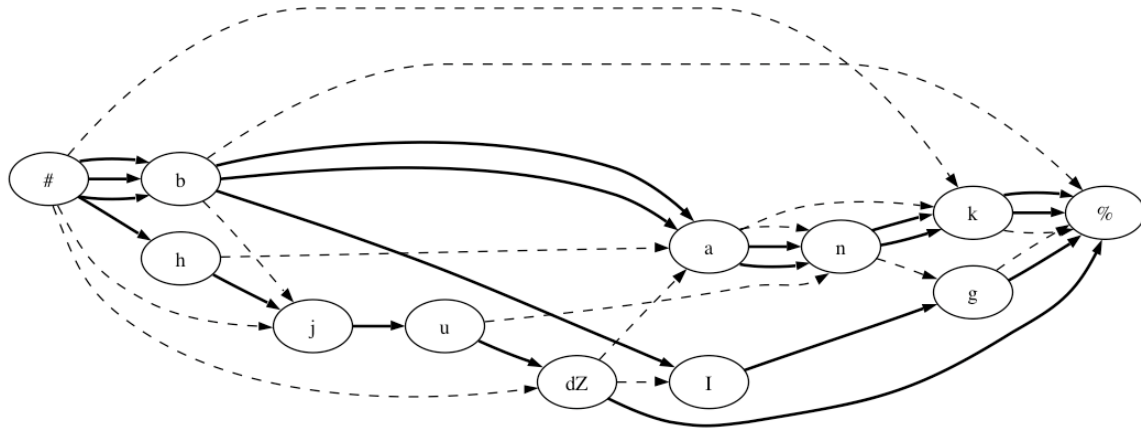
- PBP provides a basis for a novel view of the lexicon which has the potential to connect phonological representations and various psycholinguistic phenomena in a more direct manner
- A PBP lexicon is economized for storage so it only consists of a single stack for each phoneme in a particular language and the pointers in each stack (follows suggestions by Yang (2005) and the learning algorithm in Chinn and Raimy (2006))
- Following McClory and Raimy (2007), the Enhanced Edges (EE) in the stacks consist of (at least) the following information:
 - next stack
 - morphological ID
 - semantics
 - linearization codes
- The differences in EEs encode different ‘words’ by creating different paths through the PBP lexicon
- Lexical access consists of when a path from # to % is identified which matches the phonological, morphological and semantic requirements of the according to the information on the EEs
- Once this path is accessed it is projected into the morpho-phonology and is the standard PBP graph/stack representation

(23) Sketch of a PBP Lexicon

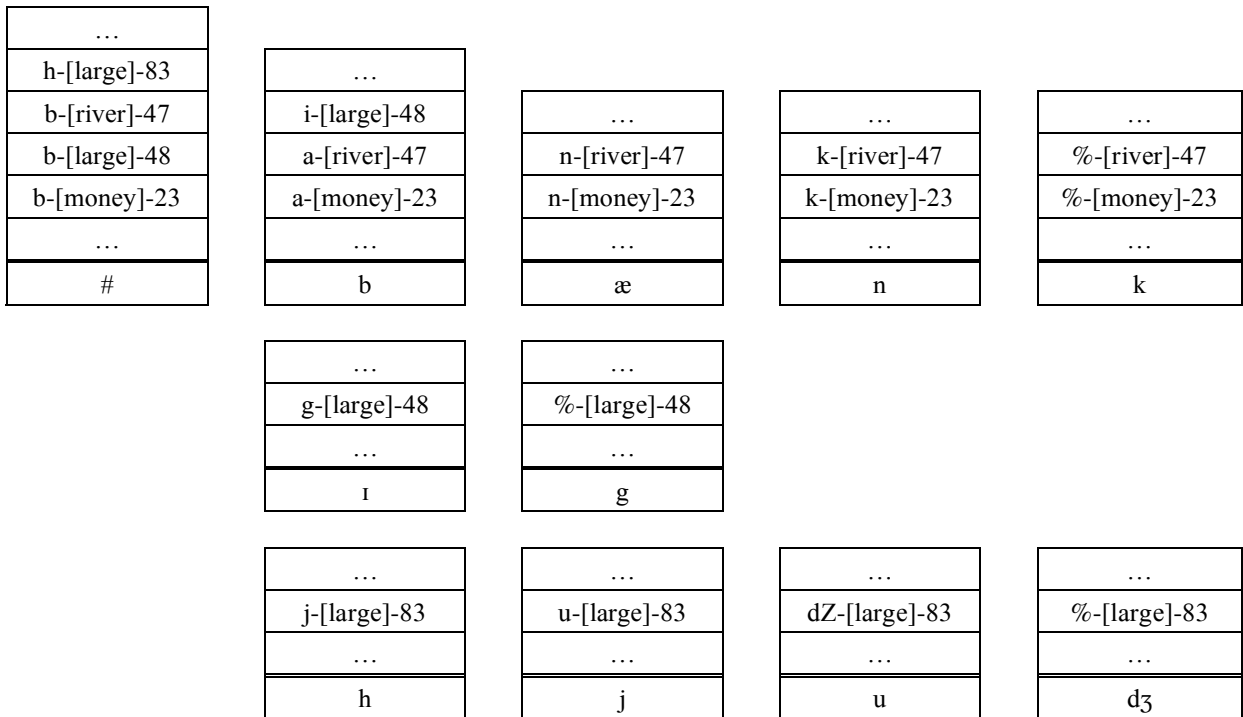
a. *Lexical Entries*

English	Phonology	Semantics	Morphological ID
bank	/bank/	[money]	23
bank	/bank/	[river]	47
big	/bIg/	[large]	48
huge	/hjudZ/	[large]	83

b. *Graph view of PBP lexicon*



c. *Stack view of PBP lexicon*



4.2 Performance of a PBP lexicon

- The stack based structure of a PBP lexicon supports proposals by Murray and Forster (2004) and Yang (2005) about the nature of lexical access
- Murray and Forster (2004) provide arguments for the *rank hypothesis* of frequency effects:
 - there is a serial search mechanism for lexical access
 - ranked list of words provides the explanation for different log based rates of access

- Yang (2005:292) discusses how frequency effects based on rank ordering of words can be accomplished with either a ‘MOVE-TO-FRONT’ or a ‘MOVE-UP’ algorithm which will cause a word to be ranked higher each time it is accessed
- We want to use this same approach for the ordering of EEs in the PBP stack where an EE would be moved higher in a stack each time ANY component of the EE is referenced (similar to Forster 1992’s parallel bin search)
- Since each EE contains phonological, morphological and semantic aspects each of these types of priming will be supported in a PBP lexicon
- Overlap of phonological, morphological and semantic information will be additive in the priming effects
- Frequency effects in a PBP lexicon then follow from the general rank hypothesis
 - EEs closer to the top of the stack- quicker access
 - EEs closer to the bottom of the stack- slower access

4.3 Specific effects in MSA

- Returning to our analysis of MSA in section 3, various psycholinguistic findings correlate well with the PBP aspect of it (consider (24))
- Priming effects are the result of the application of a ‘MOVE-UP’ algorithm on the order of EEs in the PBP lexicon stacks (consider (25))

4.3.1 Root priming

- Boudelaa and Marslen-Wilson (2000) and Frost et al. (1997) provide priming evidence in support of the *root* in Semitic languages
- PBP analysis in section 3 is supported by and supports this finding through the positing of a *root* which is marked via the morphological component of EEs
- Root priming is super-additive because all components of the EEs will cause multiple applications of the ‘MOVE-UP’ algorithm

4.3.2 Template priming

- Boudelaa and Marslen-Wilson (2004) provide priming results for *templates* based on the analysis of McCarthy (1979, 1981)
- PBP analysis in section 3 doesn’t have *templates* per se but if the particular affixes associated with different Binyanim are marked as discontinuous morphemes then we have an explanation for this effect

- Uninteresting interpretation is that all applications of the phonological pieces for each Binyan in section 3 are marked as Binyan
- More interesting interpretation is to ask whether more subtle ‘template’ priming effects are obtainable based on the further decomposition of the Binyanim according to (22); e.g. Binyan II should prime Binyan V more than Binyan XI

4.3.3 *No vowel melody priming*

- Boudelaa and Marslen-Wilson (2004) also report that they did not find evidence that vocalic melody acted as a prime
- We can understand this observation as resulting from a lack of contrast on vowels in MSA (there are only 3) which weakens phonological priming (consider (26))
- In other words, there are many different pointers that are being *phonologically primed* and so there is no significant raising of relevant pointers in this task

4.3.4 *Word pattern priming*

- Boudelaa and Marslen Wilson (2004) report that word pattern priming which consists of matching template and vowel melodies primes equally to a plain template
- From 4.3.3, the vowel melody does not add a substantial effect beyond the template information

4.3.5 *Etymon priming*

- Boudelaa and Marslen-Wilson (2001) provide evidence for *etymon* priming in MSA
- An *etymon* is a two consonant unordered level of representation in Semitic languages
- A *root* is formed from an *etymon* from the addition of a consonant and a specific ordering between the two consonants in the *etymon*
- *Etymon* priming (along with general phonaestheme effects) is the result of phonological and semantic overlap in priming and the way the MU algorithm operates across the PBP lexicon
- No need to have a level of analysis below *root*

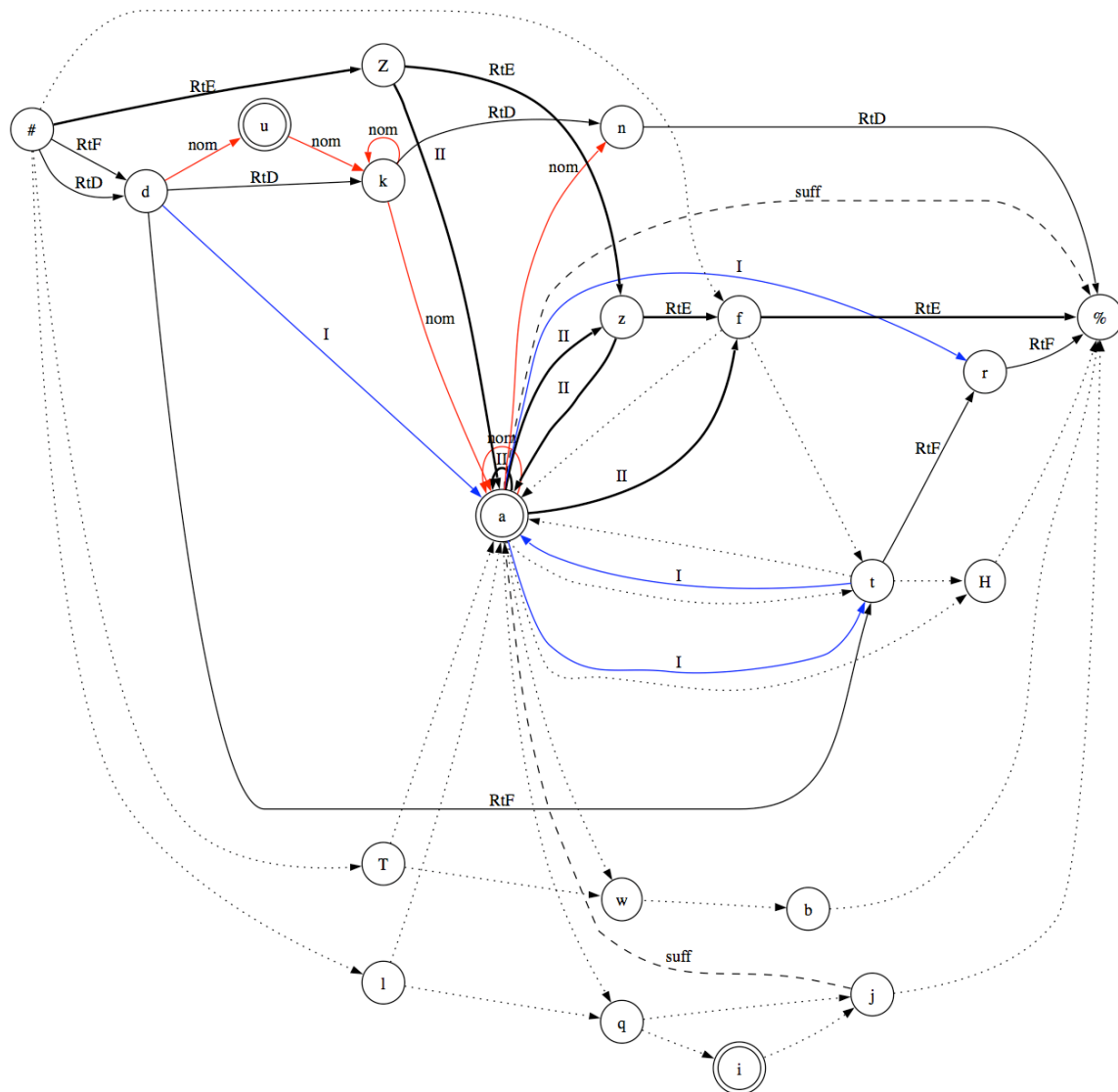
(24) PBP Lexicon of MSA for 6 words

	...		...	a-?		
Roots	a-IX		%-rtE	?-?		
{fth}B	r-rtF			d-IP		
{lqj}A	...	...	...	a		
{θwb}C	a-I	%-rtB	%-rtJ	t-IX		
{dkn}D	ħ-rtB	...	...	r-IX		
{z3f}E	...	ħ	a-I	f-II		
{dtr}F	t		t-rtB	a-II		
{wʔʔ}G			...	a-?		
{snd}H	a-II		f	n-?		
{xlf}J	f-rtJ			w-N		
		
	a-I	i-I	...	q-I	ʔ-?	
	q-rtA	j-rtB	%-rtB	t-I	...	
	...	...	...	ħ-I	j-I	k-?
x-rtJ	l	q	j	...	...	...
w-rtG				a	i	u
d-rtF						
z-rtE		...				
d-rtD	...	i-?				
q-rtP	a-N	ʔ-rtG				
q	...	...	...
q-rtS	w-rtC	b-rtC	%-rtC	a-II	a-II	
θ-rtC	...	...	...	n-rtH	l-rtJ	
f-rtB	θ	w	b	s	x	
...						
#	%-rtH		...			
	a-IX		a-II			
	t-rtF	...	d-rtH	...	...	...
Surface	u-?	k-?	...	a-?	...	...
fataħ	k-rtD	n-rtD	%-rtD	ʔ-rtG	%-rtG	%-rtF
laqija	...	...	...	...	...	...
θawb	d	k	n	ʔ	ʔ	r
dukkaan						
z3azaf						
ʔindatar	a-II	a-II				
wiʔaaʔ	z-rtE	f-rtE				
saanad	...	...		
xaalaf	z	z				

(25) Effect of 'vowel prime' condition

	...			z-II		
	a-IX		%-rtE	f-II		
Prime	a-I		a-I	a-II		
3aazaf	...		...	a-?	ʕ-?	
Target	r-rtF	...	...	f	...	
datar	ħ-rtB	%-rtB	%-rtJ	z	j-I	k-?
Control	...	...	...	r-IX	...	...
dukkān	t	ħ	...	ʕ	i	u
			t-rtB	ʔ-?		
		
	a-II		f	n-?		
	a-I			w-N		
	f-rtJ	...		...
	...	i-I	...	q-I	a-II	
	q-rtA	j-rtB	%-rtB	t-I	a-III	a-II
3-rtE	...	...	...	ħ-I	z-rtE	f-rtE
x-rtJ	l	q	j	...	...	...
w-rtG				a	ʕ	z
d-rtF						
...						
d-rtD	...	i-?				
q-rtP	a-N	ʕ-rtG				
q	...	...	...
q-rtS	w-rtC	b-rtC	%-rtC	a-II	a-II	
θ-rtC	...	...	...	n-rtH	l-rtJ	
f-rtB	θ	w	b	s	x	
...						
#	a-II		...			a
	a-IX	...	a-II			ʕ
	t-rtF	...	d-rtH	...	...	...
	u-?	a-?	...	a-?	...	...
	k-rtD	n-rtD	%-rtD	ʔ-rtG	%-rtG	%-rtF
	...	k-?	...	...	...	...
	d	k	n	ʕ	ʔ	r

(26) Graph view of PBP MSA lexicon—lack of vowel priming



5.0 Conclusion and future directions

5.1 General Points

- PBP provides a general approach to phonological representation
- PBP is not limited to any particular phenomenon and thus does not contain any phenomenon specific machinery
- PBP unifies concatenative and non-concatenative morphology in an interesting way
 - difference between these two descriptions is amount of infixation
 - universal aspect is precedence representations, specific variations are lexical items
 - directly predicts *gradient* aspects of the concatenative vs. non-concatenative range (e.g. English > Maltese > MSA)

5.2 Analysis of MSA

- PBP analysis of MSA derives templates from infixation of vowels and consonants with commonly attested Anchor Points (achieves goals of *atemplaticism*)
- ‘prosodic effects’ directly implemented from content of affixes- no strange questions of what is the template for a CCVC root (i.e. Binyanim IV and X)
- Expansion of analysis to quadriliteral and biliteral roots is accomplished by investigating the ambiguities of Anchor Point descriptions (Fitzpatrick and Nevins 2002, Yanti and Raimy 2007) of trilateral roots

5.3 Psycholinguistics

- PBP provides same representational format for the lexicon, morpho-phonology and phonology
- PBP directly supports rank based explanations of frequency and priming effects
- Potential to explain other psycholinguistic effects:
 - word well-formedness judgments–number of EEs
 - ineffability–no possible path
 - nonce words–EE paths lacking morphological, semantic, etc. mark-ups
 - development of lexicon–addition and elaboration of stacks and EEs

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