



(9) *Transparency* of high vowels in Wolof (Pulleyblank 1996). Harmony passes through:

Harmonic alternations: e/ε o/ɔ ə/a				
A.	ATR: e ə o	Transparent: i u	B.	RTR: ε a ɔ
i.	√seen. <b>u</b> .woon	'tried to spot'	i.	√xɔll. <b>i</b> .wɔɔn 'peeled'
ii.	√tər. <b>i</b> .woon	'went and slept'	ii.	√tɛɛr. <b>u</b> .wɔɔn 'welcomed'
iii.	√boo. <b>bu</b> .le	'that coat of his (topic)'	iii.	√bɔɔ. <b>bu</b> .le 'that friend of his (topic)'

(10) Span Theory as stated has no provision for transparent vowels.

**Proposal**

(11) Span structure is violable: heads determine the span's value, but span members may disagree.

(12) Examples in (9) are parsed as single spans with non-associating elements [bracketed]:

i. (se:n[u]won)	i. (xɔll[i]wɔ:n)
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**II. Span Theory in practice**

Span Theory relies on three classes of constraints<sup>2</sup>:

- (13) \*A-SPAN(F): No adjacent F-spans – i.e., one violation for every span in a candidate after the first.
- (14) FAITHHEADSPAN(αF): If an input segment  $x_i$  has value [αF] and it has a correspondent output segment  $x_o$ ,  $x_o$  will head a [αF] span.
- (15) HEAD([βG, γH, ...], [αF]): Every [βG, γH, ...] heads a [αF] span.
- (16) Recall that Akan affixes take on the ATR value of the stem: wu.be.√tu, wu.be.√tu.

Thus ATR harmony in Akan requires the following constraints:

- (17) \*A-SPAN(ATR): No adjacent ATR spans. Henceforth \*A-SPAN.
- (18) FAITHHEADSPAN(+ATR): Faith to +ATR value of input and heading. Henceforth FTHHD+.
- (19) FAITHHEADSPAN(-ATR): Faith to -ATR value of input and heading. Henceforth FTHHD-.
- (20) HEAD([-low], [+ATR]): Non-low vowels head +ATR spans. Henceforth NLHD+.
- (21) HEAD([-low], [-ATR]): Non-low vowels head -ATR spans. Henceforth NLHD-.

Akan is a clear case of stem-controlled harmony (McCarthy and Prince 1995; Bakovic 2000, 2003):

(22) FAITHSTEM: If an input segment  $x_i$  is in the stem, has value [αF], and has a correspondent output segment  $x_o$ ,  $x_o$  will head a [αF] span. Henceforth FTHSTEM.

(23) \*A-SPAN forces spreading of +ATR, i.e. reduction of specification of -ATR:

	/ɔ + √di/ → odi	*A-SPAN	FTHSTEM	FTHHD+	FTHHD-	NLHD+	NLHD-
	☞ (od <i>i</i> )	0	0	0	1	1	2
A	(od <i>i</i> ) ~ (ɔdi)	0	1 W	1 W	0 L	2 W	1 L
B	(od <i>i</i> ) ~ (ɔ)(d <i>i</i> )	1 W	0	0	0 L	1	1 L
C	(od <i>i</i> ) ~ (o)(d <i>i</i> )	1 W	0	0	1	0 L	2

A: Inconclusive at this point  
 B: \*A-SPAN >> FTHHD-, NLHD-

C: \*A-SPAN >> NLHD+

<sup>2</sup> I will use the comparative tableau notation throughout. For further information see Prince 2002a.

(24) \*A-SPAN forces spreading of -ATR, i.e. reduction of specification of +ATR:

	/o + √di/ → ɔdi	*A-SPAN	FTHSTEM	FTHHD+	FTHHD-	NLHD+	NLHD-
	☞ (ɔdɪ)	0	0	1	0	2	1
A	(ɔdɪ) ~ (o)(dɪ)	1 W	0	0 L	0	1 L	1
B	(ɔdɪ) ~ (odi)	0	1 W	0 L	1 W	1 L	2 W

A: \*A-SPAN >> FTHHD+, NLHD+

B: Inconclusive at this point

(25) Fusion of the above candidates (see Prince 2002a) provides the complete ranking:

		*A-SPAN	FTHSTEM	FTHHD+	FTHHD-	NLHD+	NLHD-
A	24B • 24C	W			L	L	L
B	26A • 25A	W		L	L	L	L
C	24A • 25B		W	L	L	L	L

B: \*A-SPAN >> FTHHD+, FTHHD-, NLHD+, NLHD-

C: FTHSTEM >> FTHHD+, FTHHD-, NLHD+, NLHD-

Opacity of /a/ (as in o.bisa.i) now requires no theory-external constraint:

(26) HEAD([+low], [-ATR]): Low vowels head -ATR spans. Henceforth LHD-.

(27) LHD- forces violation of \*A-SPAN:

	/a+√du/ → adu	LHD-	FTHSTEM	*A-SPAN	FTHHD+	FTHHD-	NLHD+	NLHD-
	☞ (a)(du)	0	0	1	0	0	0	1
A	(a)(du) ~ (ædu)	1 W	0	0 L	0	1 W	0	1

(28) LHD- and FTHSTEM force violation of \*A-SPAN:

	/√bisa/ → bisa	LHD-	FTHSTEM	*A-SPAN	FTHHD+	FTHHD-	NLHD+	NLHD-
	☞ (bɪ)(sɔ)	0	0	1	0	0	0	1
A	(bɪ)(sɔ) ~ (bɪsæ)	1 W	1 W	0 L	0	1 W	0	1
B	(bɪ)(sɔ) ~ (bɪsɔ)	0	1 W	0 L	1 W	0	1 W	1

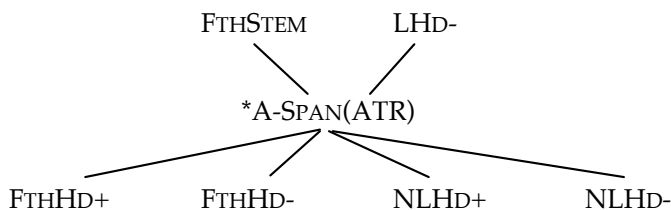
(29) Fusion with the above can give a final ranking:

		LHD-	FTHSTEM	*A-SPAN	FTHHD+	FTHHD-	NLHD+	NLHD-
A	26B • 28A	W		L	L	L	L	L
B	26C • 29B		W	L	L	L	L	L

A: LHD- >> \*A-SPAN (>>) FTHHD+, FTHHD-, NLHD+, NLHD-

B: FTHSTEM >> \*A-SPAN (>>) FTHHD+, FTHHD-, NLHD+, NLHD-

(30) Ranking for Akan:



### III. Vowel transparency: Wolof high transparency to ATR

(31) ATR values spread across high vowels; recall  $\sqrt{boo.bu.le}$ ,  $\sqrt{b\ddot{o}.bu.le}$

(32) Analysis: high vowels can't head spans. Suppose input  $/b\ddot{o} + bu + le/$ :

- i.  $*(b\ddot{o}:)(b\mathbf{u})(le)$       ii.  $*(b\ddot{o}:)(b\mathbf{u}:le)$

(33) Span structure must simply be ignoring the high vowel:

- i.  $(b\ddot{o}:b[u]le)$

(34) Gafos (1996): vowel features *must* spread over consonants and transparent vowels

Gafos and Benus (2003): phonetic evidence based on transparent vowels in Hungarian backness harmony

(35) Note emphasis (-ATR) spread such as in Palestinian Arabic (example from McCarthy 1997):

- i.  $(b\ddot{a}ll\ddot{a}ṣ)$

There seems to be a spectrum of association with spans:

(36) ASSOCHDHI: High vowels must associate with the head of their ATR span.

(37) ASSOCHDMID: Mid vowels must associate with the head of their ATR span.

(38) ASSOCHDLOW: Low vowels must associate with the head of their ATR span.

(39) ASSOCHDCONS: Consonants must associate with the head of their ATR span.

High vowels must be assigned value somehow:

(40) \*HiRTR:  $*[+high, -ATR]$

And we require the standard constraints (n.b. Wolof *high* vowels are disharmonic, as opposed to Akan *low* vowels):

(41) \*A-SPAN(ATR): No adjacent ATR spans. Henceforth \*A-SPAN.

(42) FAITHHEADSPAN(+ATR): Faith to +ATR value of input and heading. Henceforth FTHHD+.

(43) FAITHHEADSPAN(-ATR): Faith to -ATR value of input and heading. Henceforth FTHHD-.

(44) HEAD([-high], [+ATR]): *Non-high* vowels head +ATR spans. Henceforth NHHD+.

(45) HEAD([-high], [-ATR]): *Non-high* vowels head -ATR spans. Henceforth NHHD-.

(46) FAITHSTEM: If an input segment  $x_i$  is in the stem, has value  $[\alpha F]$ , and has a correspondent output segment  $x_o$ ,  $x_o$  will head a  $[\alpha F]$  span. Henceforth FTHSTEM.

(47) \*HiRTR forces violation of ASSOCHDHI:

	$/\sqrt{b\ddot{o}+bu+le}/ \rightarrow b\ddot{o}bul\epsilon$	FSTEM	*ASpan	*HiRTR	ASSOCHDHI	FTHHD+	FTHHD-	NHHD+	NHHD-
	$\varnothing (b\ddot{o}b[u]le)$	0	0	0	1	2	0	3	2
A	$(b\ddot{o}b[u]le) \sim (b\ddot{o})(b\mathbf{u}le)$	0	1 W	0	0 L	1 L	0	2 L	2
B	$(b\ddot{o}b[u]le) \sim (b\ddot{o}b\mathbf{u}le)$	0	0	1 W	0 L	2	0	3	2
C	$(b\ddot{o}b[u]le) \sim (b\ddot{o}b\mathbf{u}le)$	1 W	0	0	0 L	1 L	1 W	2 L	3 W
D	$(b\ddot{o}b[u]le) \sim (b\ddot{o}b\mathbf{u})(le)$	0	1 W	0	1	1 L	0	2 L	2
E	$(b\ddot{o}b[u]le) \sim (b\ddot{o})(b\mathbf{u})(le)$	0	2 W	1 W	0 L	2	0	3	0 L

A: \*A-SPAN >> ASSOCHDHI, FTHHD+, NHHD+

B: \*HiRTR >> ASSOCHDHI

D: \*A-SPAN >> FTHHD+, NHHD+

(48) \*A-SPAN >> ASSOCHDHI prevents opacity of  $/u/$ .

(49) \*HiRTR >> ASSOCHDHI prevents association of  $/u/$  with the -RTR span.

(50) \*HiRTR >> FTHHD- necessarily as [+high, -ATR] never surfaces.

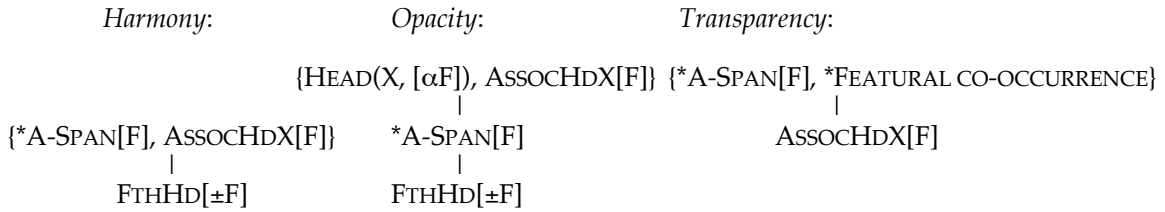
(51) FTHSTEM >> FTHHD+, FTHHD-, NHHd+, NHHd- as this language has stem-controlled harmony (like Akan).

(52) The following ranking predicts Wolof transparency:

\*A-SPAN, \*HiRTR, FTHSTEM >> ASSOCHdHi, FTHHD+, NHHd+, NHHd+, NHHd-

**IV. Predictions of theory**

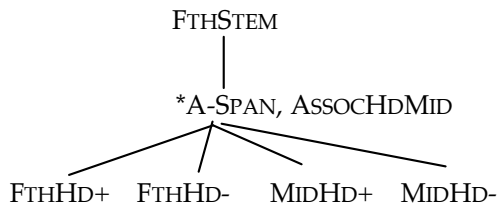
(53) Opacity and transparency emerge from the relative positions of association and heading constraints:



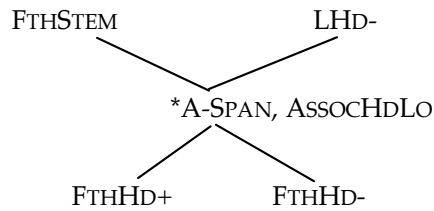
(54) Opacity and transparency can be present in one language: suppose we “conjoin” Wolof and Akan for a system with opaque low vowels and transparent high vowels:

- |                  |                  |
|------------------|------------------|
| i.     √be.te.ke | i.     √bε.te.ke |
| ii.    √be.ta.ke |                  |
| iii.   √be.ti.ke | iii.   √bε.ti.ke |

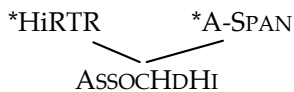
(55) “Harmony system”:



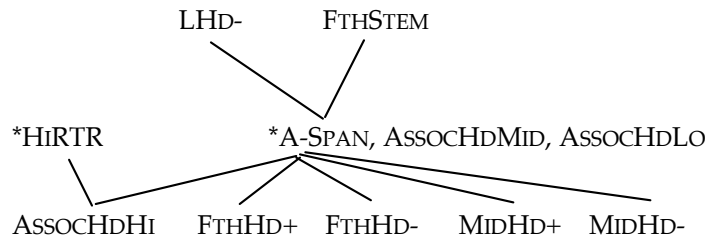
(56) “Opacity system”:



(57) “Transparency system”:



(58) Complete ranking:



(59) This ranking predicts the correct output for a hypothetical input /bebiɛ/:

	/√be+bi+be/ → bebiɛ	FSTEM	*ASpan	*HiRTR
A	☞ (bɛb[i]bɛ)	0	0	0
B	(bɛb[i]bɛ)~(bɛbɪbɛ)	0	0	1! W
C	(bɛb[i]bɛ)~(bɛ)(bɪbɛ)	0	1! W	0
D	(bɛb[i]bɛ)~(bebɪbɛ)	1! W	0	0

(60) This ranking predicts the correct output for a hypothetical input /bebaɛ/:

	/√be+ba+be/ → bebaɛ	FSTEM	LHD-
A	☞ (be)(baɛ)	0	0
B	(be)(baɛ)~(beb[a]be)	0	1! W
C	(be)(baɛ)~(bebæbe)	0	1! W
D	(be)(baɛ)~(bebabe)	1! W	1 W

Further typological predictions

(61) ASSOCHDC, \*A-SPAN >> CHD, FTHHD: spreading of features over consonants:

	/√be+bo+bi/ → beboɪ	ASSOCHDC	*A-SPAN	CHD	FTHHD+	FTHHD-
A	☞ (beboɪ)	0	0	3	2	0
B	(beboɪ)~([b]ɛ[b]ɔ[b]ɪ)	3! W	0	3	2	0
C	(beboɪ)~(b)(ɛ)(bobi)	0	2! W	2 L	1 L	0

(62) \*A-SPAN, all co-occurrence constraints >> all ASSOCHD constraints: no spreading  
Suppose we have a purely hypothetical MHYP: only /ɛ/ may be -ATR.

	/√be+bo+bi/ → bebobi	*ASpan	MHYP	ASSOCHDC	ASSOCHDV
A	☞ ([b]ɛ[b][o][b][i])	0	0	3	2
B	([b]ɛ[b][o][b][i])~([b]ɛ[b]ɔ[b]ɪ)	0	2! W	3	0 L
C	([b]ɛ[b][o][b][i])~(b)(ɛ)(bobi)	2! W	0	0 L	0 L

(63) all faithfulness constraints >> \*A-SPAN: no spreading

	/√bε+bo+bi/ → bεbobi	FTHHD	*ASpan
A	☞ (b)(ε)(b)(o)(b)(i)	0	5
B	(b)(ε)(b)(o)(b)(i)~(bεbɔbi)	5! W	0 L

(64) \*A-SPAN, FthHd[α] >> FthHd[β]: spreading of one feature value over the other

	/√bεbo/ → bεbo	*ASpan	FTHHD-	FTHHD+
A	☞ (bεbo)	0	0	1
B	(bεbo)~(bε)(bo)	1! W	0	0 L
C	(bεbo)~(bεbo)	0	1! W	0 L

## V. Conclusions and further issues

(65) Association with span heads is violable.

(66) Vowel harmony and disharmony are driven by several pressures:

- a. Pressure to be faithful
- b. Pressure to form spans
- c. Pressure to associate with spans
- d. Pressure to be less marked
  - i. Heading restrictions
  - ii. Featural co-occurrence restrictions

Each component of this system is violable, and the relative rankings determine whether vowels are opaque, harmonic, or transparent.

(67) Opacity is not an exception, but rather a stronger pressure towards a particular span type.

(68) Transparency is not an exception, but rather a weaker pressure towards association.

### *Remaining questions*

(69) What is the exact typology of transparency and opacity?

(70) To what other properties (voicing? tone?) can the span analysis apply?

Michael O'Keefe  
 18 Seminary Place  
 New Brunswick, NJ 08901  
 mcokeefe@eden.rutgers.edu

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