Transparent vowels in ABC: open issues*

Samuel R. Bowman
Stanford University

ABC↔C, May 2014

The similarity basis for correspondence in ABC does not on its own provide for a complete account of the distribution of transparency in vowel harmony, and even Rhodes's (2012) extensions to the theory leave it without adequate coverage in this domain. In this paper, I survey a few cases of vowel transparency that are not straightforwardly compatible with ABC, including transparent vowel types which have potential harmonic counterparts in the inventory, morphologically idiosyncratic transparency, and transparency that is sensitive to syllable count or syllable position. I show that some modest extensions to the theory allow for accounts for all of these, but also contrast these new accounts with potentially simpler ones under Kimper's (2011) Trigger Competition, a competing theory focused exclusively on vowel harmony.

1 Introduction

(1) **What governs which segments are transparent to vowel harmony?**
  a. Opaque vowels don't undergo harmony and interrupt the spread of harmony:
     $[+f][+f][-\mathbf{f}][-f] \rightarrow$
  b. Transparent vowels don't undergo harmony, but allow harmony to pass over them:
     $[+f][+f][-\mathbf{f}][+f] \rightarrow$

(2) Founding idea of ABC: Correspondence depends on similarity, and is enforced among members of natural classes.

(3) It is not usually possible to define a natural class of vowels that participate in harmony to the exclusion of the transparent vowels (Walker, 2013).

*The documentary work on Kazakh was done jointly with Benjamin Lokshin in consultation with speakers Dana Kismetova and Yeskendir Kassenov. I also owe thanks to Paul Kiparsky, Arto Anttila, Vera Gribanova, Rob Podesva, Stephanie Shih, and Sharon Inkelas for their advice, and to audiences at Stanford, Berkeley, Edinburgh, 21mfm, WAFL9, Phonology, CLS 49 and the 86th LSA for their comments on various portions of this work.

(4) Transparency is a fairly direct test of the theory: Opaque vowels can be opaque because some other constraint prevents them from undergoing harmony. (markedness of the result, positional faithfulness...) Transparent vowels must be ignored by the harmony system to stay transparent.

(5) Goal for today: highlight cases of vowel transparency that are not compatible with ABC as it stands.

(6) NB: This is an **open issues** talk. For many of these cases there is no easy fix.

2 The current approach to transparent vowels

(7) Rhodes's (2012) proposes **weak specification**, a method for generating transparent vowels that cannot be explained by the similarity basis alone.

(8) The proposal:

> If vowels contrast with each other based only on carrying the opposite [BACK] values, both vowels are strongly specified (e.g., /a/ and /ä/ differ only in backness, so they are strongly specified for the feature). If, however, a vowel does not contrast with any other vowel based only on carrying opposing [BACK] values, that vowel is weakly specified. (Rhodes, 2012)

(9) Theoretically doubles the number of feature values available, but something needs to be done to account for these cases.

(10) He uses this to **enforce correspondence only between strong (i.e., harmonically contrastive) vowels** using a variant correspondence constraint, **CorrV$_S$V$_S$**, thereby preventing the weak vowels from participating in harmony.

(11) The Finnish inventory, from Rhodes:

strength	*	*	**	**	**	**	**	**
value	-	-	-	-	-	+	+	+
segments	i	e	y	ö	ä	u	o	a

(12) An example from Finnish, from Rhodes:

/vero-llä/	CORRV$_S$V$_S$	IDENT-VV(BK)	IO-IDRT(BK)	CORRVV	IO-IDENT(BK)
a. ☞ [vero$_i$-lla$_i$]				1	1
b. [ve$_i$rö$_i$-llä$_i$]			1W	L	2W
c. [ve$_i$ro$_i$-llä$_i$]		2W		L	1
d. [ve$_i$ro-llä$_i$]	1W			2W	L

(13) This allows us to generate many cases of transparency, but it is not sufficient: There are cases of transparency that are not predictable either by the similarity basis or Rhodes's contrastiveness basis.

3 Transparent vowels and the structure of the inventory

(14) Major class of problems for weak specification: Transparent vowels that are not predicted by the similarity basis, and are contrastive for the harmonizing feature.

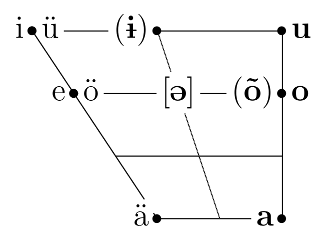
3.1 Paired transparent vowels: Seto /i/

Data from Kiparsky and Pajusalu (2001) manuscript, analysis first presented in Bowman (2013).

(15) Seto: spoken in southern Estonia, Finno-Ugric, ~10,000 speakers.

(16) **Progressive backness harmony** with neutral vowels.

(17) **Inventory:** () = only appears in the initial (stressed) syllable, [] = does not appear in the initial (stressed) syllable, **bold** = back vowel



(18) /i/ is transparent:

a. *ilma* 'without' ~ *hinneq* 'fiber'

b. *opp:a-ji-lə* 'teacher-PL-ALL' ~ *rebäs-i-le* 'fox-PL-ALL'

(19) /i/ appears to have a counterpart in the inventory that is back-harmonic and differs only in backness: /ɨ/

(20) *sɨna* 'word' ~ *ilma* 'without' ~ *hinneq* 'fiber'

3.1.1 Provisional analysis

(21) Not the only case! Kimper (2013) points out similar cases in Kinande and Khalkha.

(22) /i/ must be [-BACK, -STRONG] and ɨ must be [+BACK, +STRONG]: Rhodes's definitions require the two vowels to be both contrastive and not contrastive for [BACK].

(23) We need a more a permissive theory.

a. Simplest option so far: implement a **weaker version of the theory of specification strength** that allows at least some vowel types to be freely specified as weak or strong.

3.2 Position-sensitive transparency

(24) **Bigger problem** for the existing approaches: Vowel types that are transparent only in some environments.

3.2.1 Seto, continued

(25) Seto /e/ is **transparent word initially**, and undergoes harmony elsewhere:

(26) a. *teeda* 'grandpa' ∼ *esä* 'father'
b. *opp:a-ji-lə* 'teacher-PL-ALL' ∼ *rebäs-i-le* 'fox-PL-ALL'

(27) Transparent /e/ is another example of paired vowel transparency: it differs from /õ/ only in backness.

3.2.2 Korean sound-symbolic words

Data and description from Larsen and Heinz (2012). See also Cho and Inkelas (1993).

(28) This vowel harmony system is restricted to the sound-symbolic portion of the lexicon, and uses the feature [LIGHT].

(29) Light and dark words have different connotations:

light: brightness, lightness, sharpness, quickness, smallness, thinness
dark: darkness, heaviness, dullness, slowness, deepness, thickness

(30) They often come in alternating pairs:
a. p^huŋtʌn – 'splash' (sound of large object hitting water)
b. p^hoŋtan – 'splash' (sound of small object hitting water)

(31) The inventory. Vowels in shaded cells are [-LIGHT], and other vowels are [+LIGHT].

	front	front round	central	back (round)
high	i*	y	ɨ*	u
mid	e	ø	ʌ	o
low	æ		a	

(32) /i/ and /ɨ/ are **transparent non-initially**:
a. c'alɨlɨk−c'alɨlɨk – sound of sucking water with difficulty (e.g. with a straw)
b. pulɨliŋ−pulɨliŋ – 'with a burr (of a combustion engine)'

(33) They generally only occur word-initially only in [-LIGHT] harmonic words.

(34) Statistical study. Words with {i, ɨ}...[+LIGHT] sequences are attested vastly less often than would be predicted in the absence of harmony.

3.2.3 Provisional analysis

(35) The transparent and non-transparent vowels are equally similar to the remaining harmonizing vowels, and equally contrastive for the harmonizing feature.

(36) How can we get the harmony system to distinguish them? I see three options.

(37) **Pull apart each phoneme.** For Seto, for example:
a. Seto [e] is underlyingly /e_1/ word initially, /e_2/ elsewhere.
b. /e_1/ is specified as [-BACK, -STRONG], /e_2/ is specified as [-BACK, +STRONG]

c. Positional markedness constraints /e_2/ from surfacing word-initially, and prevent /e_1/ from surfacing non initially, as with /õ/ and /ə/: Since /e_1/ and /e_2/ differ only in specification strength, these constraints would attempt to align certain positions with certain specification strengths.

(38) No independent phonetic or phonological evidence to motivate a split.

(39) **Position-sensitive strength**:

a. Stipulate that Seto [e] is weakly specified for backness word initially.

b. Not ideal: Even if we are forced to stipulate strength specifications at a type level, desirable to keep that context insensitive just like the rest of a vowel's underlying features.

(40) **Quality sensitive corr**: Create a constraint that enforces correspondance only when the lefthand correspondant is not an initial /e/. Typological nightmare?

(41) Note that it may still be possible to maintain fairly strong generalizations about which segments tend to be transparent: the Seto transparent vowels are exactly the non-low front unrounded vowels that tend to be transparent in backness harmony systems crosslinguistically.

4 Morphologically idiosyncratic transparent vowels

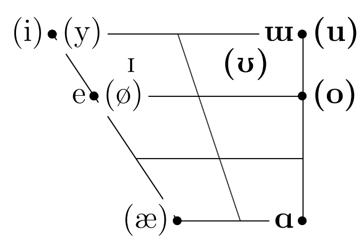
5 Kazakh

Published as Bowman and Lokshin (2014).

(42) **It gets worse:** transparency may not be predictable even given vowel type *and* local phonological context.

(43) Kazakh has a robust system of progressive backness harmony[1] that applies to all suffixes and all native roots.

(44) Our inventory: () = only appears in the initial syllable, **bold** = back vowel



(45) Seven of the vowels show up only word-initially in native words, and do not appear in suffixes, and so do not alternate:

[1]We describe a harmony system with the typologically typical [±Back] contrast, though our purely acoustic observations cannot rule out a similarly structured [±RTR] system, as was proposed by Vajda (1994).

non-alternating front		non-alternating back
Ү [y]		У [u](/[w])[2]
И [i](/[j])		Ұ [ʊ]
Ө [ø]		О [o]
Ә [æ][3]		
alternating front		alternating back
І [ɪ]	∼	Ы [ɯ]
Е [e]	∼	А [ɑ]

(46) Most suffixes show alternating front and back variants which harmonize with the stem. **Suffix harmony is categorical**: we have found no stems which can be followed by both front and back affix variants.

a.	BACK:	ɑɣɑs-tɑr-dɑn	*ɑɣɑs-tʲer-dʲen	'tree-PL-ABL'
b.	FRONT:	*ijt-tar	ijt-tʲer	'dog-PL'

(47) We have identified two cases of transparency in Kazakh which follow a pattern not previously observed.

(48) **The infinitive suffix** constitutes a more robust and unusual case. It is realized as an offglide [w] following a vowel, or [uw] following a consonant, regardless of harmonic context:

a. V-: qɑrɑ-w 'look-INF' ('to look')

b. BACK VC-: qoj-uw 'quit-INF' ('to quit')

c. FRONT VC-: kʲel-uw 'enter-INF' ('to enter')

d. mʲen jesɪk-tɪ ʒɑb-uw-dɯ yjrʲen-dɪm
1SG door-ACC lock-INF-ACC learn-1SG
I learned to lock the door.

(49) Alternating affixes following INF will look past it to harmonize with the stem, shown with the front-harmonic cases here:

a.	ʒyz-uw-dɪ	*ʒyz-uw-dɯ	'take-INF-POSS.3'
c.	kɪr-uw-dɪ	*kɪr-uw-dɯ	'enter-INF-ACC'

(50) INF is the only native morpheme to violate the inventory generalizations above. Can be analyzed using lexically indexed faithfulness (in the style of Pater, 2009).

(51) There have been claims that INF has two surface forms and is harmonic in Kazakh. Phonetic evidence for our speakers is inconclusive (see Bowman and Lokshin, 2014).

(52) The harmonic behavior of **The comitative suffix** has not been documented to our knowledge, and it shows a variant of the same anomalous behaviour seen with INF.

[2] Orthographic 'У' seems to represent [w] in at least some cases when it follows a vowel. Whether this is an orthographic convention or a phonological reduction process from underlying /u/ is not of consequence here. И shows similar behavior.

[3] /æ/ appears to be heavily restricted in non-loan words, and Vajda claims that it is not part of the native phonology. Our study does not attempt to address this issue, but the vowel does appear in a large number of basic vocabulary items:

a.	ækʲe	'father'	b.	æpkʲe	'aunt'
c.	æʒʲe	'grandmother'	d.	dæn	'seed'

(53) The comitative suffix /mʲen/ (/pʲen/ or /bʲen/ in some consonantal environments) is also non-alternating:

a.	BACK:	ɑdɑm-mʲen	*ɑdɑm-man/-mɯn	‘person-COM’
b.	FRONT:	ystyl-mʲen	*ystyl-man/-mɯn	‘table-COM’

(54) We have only found one affix that can follow COM, but this affix shows that it too is **transparent**:

a. bʊl ʃal nɑn-mʲen-bɑ
this old.man bread-COM-Q
Is this an old man with some bread?

b. bʊl ʃal ʒʊmbɑq-pʲen-bɑ
this old.man puzzle-COM-Q
Is this an old man with a puzzle?

c. bʊl ʃal bøbʲek-pʲen-bʲe
this old.man baby-COM-Q
Is this an old man with a baby?

d. bʊl ʃal syt-pʲen-bʲe
this old.man milk-COM-Q
Is this an old man with milk?

(55) COM is less troublesome than INF, since there are **other suffixes containing the same vowel** that participate in harmony normally, like PTCP shown here:

a. tɪstʲe-gʲen-ɪ ‘bite-PTCP-POSS.3’

b. ɑudar-ɣɑn-ɯ ‘turn.over-PTCP-POSS.3’

5.1 The status of idiosyncratic transparency

(56) Idiosyncratic *opaque* affixes are fairly common (e.g. Baković, 2000).

(57) As recently as Mahanta (2012), idiosyncratic transparent vowels were claimed to be unattested and impossible.

(58) A potential case of idiosyncratic transparent affixes have been documented only in Karimojong (Paul Kiparsky, personal correspondence, 2013; Lesley-Neuman, 2007), but have been explained as a problem of morpheme ordering rather than of harmony, an option not viable for Kazakh.

5.2 Provisional analysis

(59) Specification strength must be allowed to be lexically specified: CORR needs some reason to ignore the morpheme:

a. Methods like indexed faithfulness on their own will produce opaque vowels.

b. Indexed cophonologies aren’t a good option, since we need harmony to work as usual across the transparent vowel.

6 Comparisons: Trigger Competition

(60) Trigger competition (Kimper, 2011): The most powerful theory that I'm aware of in constraint based grammar for dealing with vowel transparency.

(61) Power isn't always a good thing, but it was designed to do a better job with cases like the ones we've just seen.

(62) Core idea: Each segment that undergoes harmony gets its feature value from a specific trigger, but can then go on to trigger harmony for that feature on other segments.

(63) Two core factors influencing transparency:

a. **Trigger strength:** Every vowel type has a (scalar) strength that determines how well it triggers harmony.

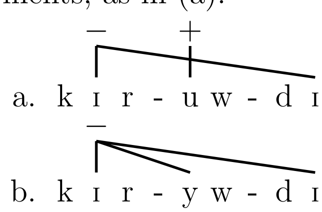
b. **Distance penalty:** This strength decays with the distance from the trigger to its target.

(64) Hypothesis (from Kimper): Trigger strength is at least partly predictable on the basis of how well a segment is perceptually cued for a feature.

(65) No theory of consonant assimilation or dissimilation.

6.1 Definitions

(66) Trigger competition uses **autosegmental representations** with crossing lines, and captures transparency by allowing the lines indicating harmonic linking to skip segments, as in (a):



(67) Set in **Serial Harmonic Grammar** (SHG, Pater et al., 2008, Pater, 2010, Mullin, 2010): the grammar is allowed to make only one step in each tableau, and repeats evaluation until no further changes are optimal.

(68) Harmony is enforced by the positively formulated constraint **Spread**, which compels segments to spread their feature values onto other segments by forming autosegmental links:

Spread[F] – Assigns one mark for every additional segment linked to a value of feature F.

a. A trigger strength factor, specified separately for each vowel, is multiplied by the assigned score to increase it when spreading originates from vowels that are weakly acoustically cued for F. Here, this is set to 5 for all normally alternating vowels.

b. A distance factor, usually a fraction, is multiplied by the assigned score once for every vowel token that is skipped between trigger and target.[4]

(69) In this simple harmony example from Kazakh, the optimal first step (shown) is to spread from the initial syllable:

− + /ijt-tɑr/	InitID −20	IndxID −20	*{iuyʊoøæ} −10	Spr[±Bk] +1	$\mathcal{H}$
a. − + ijt-tɑr	0	0	0	0	0
☞ b. − ijt-tʲer	0	0	0	5	5
c. + ɯt-tar	1	0	0	5	-15

(70) After this, no other change[5] is optimal and the derivation **converges**:

− /ijt-tʲer/	InitID −20	IndxID −20	*{iuyʊoøæ} −10	Spr[±Bk] +1	$\mathcal{H}$
☞ a. − ijt-tʲer	0	0	0	5	5
b. − − ijt-tʲer	0	0	0	0	0
c. − − ijt-tʲerɪ	0	0	0	5	5
d. − + ijt-tɑr	0	0	0	0	0

(71) **Transparent vowels** result from a conspiracy between two things: Segments that are prevented from alternating by some other constraint are neutral, and neutral segments with low trigger strengths will not interact with harmony, and are transparent.

6.2 Seto in TC

(72) Since TC doesn't require that neutral vowels be harmonically un-paired, so /i/ can be straightforwardly assigned a low trigger strength.

[4]The unit for measuring distance was left unspecified in (Kimper, 2011), though vowel tokens are more practical than morae for the cases here.

[5]I include candidate *c* to show that the positive spread constraint doesn't actively encourage the epenthesis of harmonic vowels. We assume that some constraint against epenthesis (not shown) would prevent this candidate from even tying with the normal harmony candidate, *a*.

(73) TC still assumes that trigger strength goes with vowel type, so we do need to (as in ABC) either split the phoneme /e/ in two, or else allow for context sensitive specification.

(74) Korean works similarly, though with the added issue of restricting harmony to the appropriate subset of the vocabulary.

6.3 Kazakh in TC

(75) An indexed constraint (already needed to keep /u/ from neutralizing in INF) can force INF and COM to be neutral.

(76) As in ABC, it is necessary to posit that transparency can be **learned as a property of a morpheme.** Here, this takes the form of learning a weaker trigger strength for /u/ in INF and /e/ in COM than for other tokens of those vowels.

(77) Note that an **indexed identity constraint** is crucial to prevent INF from undergoing harmony, not just for preventing it from neutralizing: unlike in ABC, we cannot leave it out in accounting for COM.

6.4 Trigger competition, quality, and distance: Hungarian

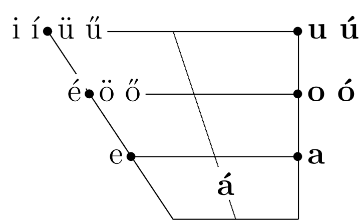
Data from Ringen and Vago (1998), Benus et al. (2003), and Hayes and Londe (2006), analysis first presented in Bowman (2013) and based on work in Kimper (2011).

(78) So far, TC doesn't offer significantly cleaner descriptions than modified ABC.

(79) The use of this relatively complex single harmony constraint allows for interactions between distance and trigger strength that we wouldn't see otherwise. **Hungarian** provides an example of why this is valuable.

(80) **Progressive backness harmony:** Hungarian vowel harmony generally spreads the value of [BACK] forward through a word stem and onto any suffixes (Ringen and Vago, 1998, Benus et al., 2003, Hayes and Londe, 2006).[6]

(81) **Inventory**: **bold** = back vowel, acute accent (´) = contrastively long.



(82) Four front vowels are **neutral**: do not alternate, can occur after back vowels: /i/, /í/, and /é/ are transparent, and /e/ is partially transparent (translucent?).

[6] Hungarian backness harmony shows some behaviors like context-dependant anti-harmony that don't have obvious analyses in ABC, TC, or any other framework that I'm aware of. See Törkenczy (2013) for a survey.

(83) Different combinations of them participate to varying degrees, yielding transparency, opacity, or optionality:

a.	**Transparency** with a single TV:	*papír-ban*	∼	**papír-ben*	'paper-INESS'
b.	**Optionality** with /e/:	*ágnes-ban*	∼	*ágnes-ben*	'Agnes-INESS'
c.	**Optionality** with two TVs:	*oxigén-ban*	∼	*oxigén-ben*	'oxygen-INESS'
d.	**Opacity** with TV plus /e/:	**kabinet-ban*	∼	*kabinet-ben*	'administration-INESS'

(84) Difficult to generate without making reference to all four cases in the grammar Hayes and Londe (c.f. 2006)

(85) The setup in TC:

a. Back vowels are **strong triggers** (trigger strength of 4).

b. The translucent /e/ is a **weaker trigger** (2).

c. The transparent /i/, /í/, and /é/ are **weaker still** (1).

d. The distance multiplier is equal (or approximately equal) to the ratios between these (0.5).

(86) A single transparent vowel allows harmony to propagate past it:

+ − − /p a p í r+b e n/	STEMID[±BK] −5	SPREAD[±BK] +1	$\mathcal{H}$
a. + − − p a p í r+b e n	0	0	0
b. + − p a̲ p í r+b e n	1	4	−1
☞ *c.* + − p a̲ p í r+b a n	0	$4 \times .5^1$ $= 2$	2
d. + − p a p í̲ r+b e n	0	1	1

(87) A single token of the translucent vowel /e/ leads to tied[7] harmony:

[7] While not every learning algorithm would have an easy time learning an exact tie precisely, it is possible to use Noisy HG (Jesney, 2007) or MaxEnt HG Goldwater and Johnson (2003), as variation emerges from *near* ties in these systems (cf. Zymet, this workshop). Adjusting the weights slightly in these systems makes it possible to match the observed frequencies of each variant fairly accurately.

[+ − −] /ágnes+ben/	StemID[±Bk] −5	Spread[±Bk] +1	$\mathcal{H}$
a. [+ − −] ágnes+ben	0	0	0
b. [+ −] <u>á</u>gnas+ben	1	4	−1
c. ☞ [+ −] <u>á</u>gnes+ban	0	$4 \times .5^1$ $= 2$	2
d. ☞ [+ −] ágn<u>e</u>s+ben	0	2	2

(88) Two transparent vowels also produce a tie:

[+ − − −] /oxigén+ben/	StemID[±Bk] −5	Spread[±Bk] +1	$\mathcal{H}$
a. [+ − − −] oxigén+ben	0	0	0
b. [+ − −] <u>o</u>xɨgén+ben	1	4	−1
c. ☞ [+ − −] <u>o</u>xigén+ban	0	$4 \times .5^2$ $= 1$	1
d. ☞ [+ − −] oxig<u>é</u>n+ben	0	1	1
e. ☞ [+ − −] ox<u>i</u>gén+ben	0	1	1

(89) A transparent vowel followed by /e/ produces opacity:

+ − − − /kabinet+ben/	StemID[±Bk] −5	Spread[±Bk] +1	$\mathcal{H}$
a. kabinet+ban (+ − − −)	0	0	0
b. kabinet+ben (+ − −)	0	$4 \times .5^2$ = 1	1
☞ c. kabinet+ben (+ − −)	0	2	2
d. kabinet+ben (+ − −)	0	1	1
e. kabɨnet+ben (+ − −)	1	4	−1

6.5 Handling distance in ABC

(90) Plain ABC does not provide a way of handling distance sensitivity:

a. Could add a constraint against skipping (penalizes vowels which have neighbors on both sides that correspond with one another): Too many solutions. Kimper (2011) shows that this predicts languages in which transparent vowels are deleted exactly when harmony would skip over them. (See also McMullin, this workshop.)

b. Shih and Inkelas (2013) propose distance-sensitive CORR constraints.

(91) Need a way of encoding a three-way strength contrast.

(92) If we have one: implement a stringency hierarchy of distance and quality sensitive constraints.

CORR-$V_{str}V_{str}$:$0\sigma \gg$
CORR-$V_{str}V_{str}$:1σ, CORR-$V_{mid+}V_{mid+}$:$0\sigma \gg$
CORR-$V_{str}V_{str}$:2σ, CORR-VV:0σ
Where MID = {e}, WEAK = {i, í, é}

(93) Should capture the Hungarian facts, but requires arbitrarily many copies of the constraint for decaying distances, and allows for arbitrary count effects.

(94) Should the strength contrast be only three-way?

7 Conclusions

(95) Rhodes's specification strength mechanism isn't enough to generate all attested cases of transparency:

a. Need to unlink inventory structure from transparency.

b. Need to allow for context-sensitive transparency.

c. Need to allow for morphologically idiosyncratic transparency.

d. Need to allow for distance sensitivity and distance-quality interactions.

(96) Some options:

a. Use a revised ABC with these features (loosely sketched here).

b. Introduce a Spread-like correspondance constraint into ABC with scalar trigger strengths and distance sensitivity.

   i. In TC, this is the main way that transparency is created. ABC has it both ways by allowing (unnecessary?) transparency based on lack of similarity.

c. ABC coexisting with trigger competition?

   i. Spread functions well on its own. Not clear that any empirical coverage would be gained by connecting it to the ABC correspondance system.

   ii. Spread depends on scalar violations, so ABC would have to be evaluated in harmonic grammar.

   iii. Spread could likely be adapted to a parallel grammar more or less in tact, but it would predict both deletion of transparent vowels and some infinite-length candidates.

References

Eric Baković. *Harmony, Dominance and Control*. PhD thesis, Rutgers University, 2000.

Stefan Benus, Adamantios Gafos, and Louis Goldstein. Phonetics and phonology of transparent vowels in Hungarian. In *Proceedings of the 29th Annual meeting of the Berkeley Linguistic Society*, pages 485–497, 2003.

Samuel R. Bowman. Two arguments for vowel harmony by trigger competition. In *Proceedings of the 49th Annual Meeting of the Chicago Linguistic Society (earlier version available as ROA#1181)*, 2013.

Samuel R. Bowman and Benjamin Lokshin. Idiosyncratically transparent vowels in kazakh. In *Proceedings of the 2013 Meeting on Phonology*, 2014.

Young-mee Y. Cho and Sharon Inkelas. A brief history of Korean vowels. Paper presented at the Sound Change Workshop, Stanford University, 1993.

Sharon Goldwater and Mark Johnson. Learning ot constraint rankings using a maximum entropy model. In *Proceedings of the Stockholm workshop on variation within Optimality Theory*, pages 111–120. Citeseer, 2003.

Bruce Hayes and Zsuzsa C. Londe. Stochastic phonological knowledge: The case of Hungarian vowel harmony. *Phonology*, 23(01):59–104, 2006.

Karen Jesney. The locus of variation in weighted constraint grammars. Poster presented at the Workshop on Variation, Gradience and Frequency in Phonology, Stanford University, 2007.

Wendell Kimper. Neither necessary nor sufficient: Re-thinking the role of contrast in vowel harmony. Poster presented at 21mfm, available at `http://personalpages.manchester.ac.uk/staff/wendell.kimper/mfmposter.pdf`, 2013.

Wendell A. Kimper. *Competing triggers: Transparency and opacity in vowel harmony*. PhD thesis, University of Massachusetts Amherst, 2011.

Paul Kiparsky and Karl Pajusalu. Seto vowel harmony and the typology of disharmony. Unpublished ms., Stanford University, 2001.

Darrell Larsen and Jeffrey Heinz. Neutral vowels in sound-symbolic vowel harmony in korean. *Phonology*, 29(03):433–464, 2012.

Diane Lesley-Neuman. *ATR harmony in Karimojong verbs: Justification for a stratal optimality theory*. PhD thesis, University of Colorado at Boulder, 2007.

Shakuntala Mahanta. Locality in exceptions and derived environments in vowel harmony. *Natural Language & Linguistic Theory*, 30(4):1109–1146, 2012. ISSN 0167-806X. doi: 10.1007/s11049-012-9173-5.

Kevin Mullin. Strength in harmony. Ms., University of Massachusetts, Amherst, 2010.

Joe Pater. Morpheme-specific phonology: Constraint indexation and inconsistency resolution. In *Phonological argumentation: Essays on evidence and motivation*, pages 123–154. Equinox. London, 2009.

Joe Pater. Serial harmonic grammar and Berber syllabification. In *Prosody Matters: Essays in Honor of Lisa Selkirk*. London: Equinox Publishing, 2010.

Joe Pater, Paul Boersma, and Andries Coetzee. Lexically conditioned variation in harmonic grammar. In *OCP-5 Université de Toulouse-Le Mirail*, 2008.

Russel Rhodes. Vowel harmony as agreement by correspondence. UC Berkeley Phonology Lab Annual Report, 2012.

Catherine Ringen and Robert Vago. Hungarian vowel harmony in optimality theory. *Phonology*, 15(3):393–416, 1998. ISSN 0952-6757.

Stephanie S Shih and Sharon Inkelas. A subsegmental correspondence approach to contour tone (dis) harmony patterns. In *Proceedings of NELS 44*, 2013.

Miklós Törkenczy. The close-ups can get rough: exceptional behaviour, transparency & variation in Hungarian vowel harmony. In *handout from 21mfm*, 2013.

Edward Vajda. Kazakh phonology. In *Opuscula Altaica: Essays Presented in Honor of Henry Schwarz*, pages 603–650. Western Washington University, 1994.

Rachel Walker. Consonant harmony and vowel harmony: comparisons in typology and sources for nonlocality. Talk at 21mfm, 2013.