Transparency and blocking

Peter Jurgec
peter@jurgec.net

July 27, 2011

Today's Outline

(1) a. The focus of this class is on transparent segments and blockers.
b. Transparency is a marked configuration. However, not all transparent segments are equally marked.
c. In the current approach, transparency is attributed to the targeted structure of alignment constraints.
d. Blocking differs in major ways from transparency.
e. Blocking is an inherently less marked than transparency. No constraint is violated by a transparent segment but not by a blocker.

---

1 Introduction

(2) Both transparent segments and blockers are traditionally described as lacking the spreading feature.

(3) As we have seen several times so far, assimilation does not need to target a contiguous string of segments.

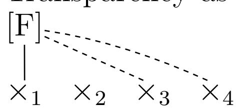
(4) Vowel harmony, for example, typically does not affect consonants.

(5) Example: Front/back harmony in Finnish does not affect consonants (Ringen 1975/1988:77; Ringen & Heinämäki 1999:305)

næh-køːn	'see-DIRECT.SG'	tul-koːn	'come-DIRECT.SG'
næk-ø	'sight'	tul-o	'coming'
pøytæ-næ	'table-ESSIVE'	poutɑ-nɑ	'fine weather-ESSIVE'

(6) In classic Autosegmental Phonology, transparency is represented as a gapped configuration (7).

(7) Transparency as a gapped configuration



(8) In the representation in (8), $\times_2$ is not associated with the feature and transparent.

(9) Blockers also lack the spreading feature. Blocking is standardly attributed to an incompatibility between the spreading feature and some other feature of the target.

(10) Example: Stops block nasal harmony in Applecross Gaelic (Ternes 1973:134,135)

ˈã̲h̃ũç̃	‘neck’
f̃r̃ɪ̲̃ã̲ˑṽ	‘root.PL.’
k^{h}ɔˈṽɪ̲̃ã̲ˑt	‘how much/many?’
str̃ã̲ɪ̲̃ˑɣ̊̃	‘to be luxurious’
ˈk^{h}ɔ̲̃ɪ̲̃s̃paxk	‘wasp’
ˈt^{h}ã̲h̃ũs̃k	‘fool’

(11) Blockers cannot be skipped by a feature.

2 Two case studies

2.1 Nasal harmony

(12) Nasal harmony is likely one of the best understood assimilation patterns, both in terms of phonetics and phonology (Schourup 1973; Cohn 1990, 1993; Walker 1998/2000, 2003; Piggott & van der Hulst 1997; Piggott 2000, 2003, inter alia)

(13) Blocking in nasal harmony involves an implicational pattern.

(14) Blocking of nasal harmony

a. Blocked by all consonants: Sundanese (Robins 1957:91,95)

m̲ãwur	‘to spread’
ŋ̲ãjak	‘to sift’
m̲ãro	‘to halve’
ŋ̲ũliat	‘to stretch (INTR.)’
ŋ̲ũdag	‘to pursue’
ŋ̲ãtur	‘to arrange’

b. Blocked by all consonants except glides: Johore Malay (Onn 1980:45)

baŋ̲õn	‘to rise’
m̲ãj̃ãŋ	‘to cause to cry’
m̲ẽw̃ãh	‘to be luxurious’
m̲ə̃ratappi	‘to cause to cry’
m̲ãkan	‘to eat’
n̲ãẽʔ	‘to ascend’

c. Blocked by obstruents: Epena Pedee (Harms 1985:16; Harms 1994: 4–6)

mɪ̲̃mɪ̲̃ə̃ɲãã	‘work a lot’
w̃ã̲ɪ̃^{n}t^{h}ee	‘go.FUT’
nã̲w̃ẽ	‘mother’
peɾ̃õ̲ɾ̃ã	‘guagua (animal)’
k^{h}ɪ̲̃^{n}siə	‘think’
mẽ̲^{n}dewe	‘blind snake’

d. Blocked by stops: Applecross Gaelic (Ternes 1973:134,135)

ˈã̰h̃ũç̃	'neck'
f̃r̃ḭ̃ã˞ṽ	'root.PL.'
kʰɔˈṽḭ̃ã˞t	'how much/many?'
str̃ã̰ĩ˞ỹ̥	'to be luxurious'
ˈkʰɔ̰̃ĩs̃paxk	'wasp'
ˈtʰã̰h̃ũs̃k	'fool'

VOWELS	GLIDES	LIQUIDS	FRICATIVES	OBS. STOPS	EXAMPLE LANGUAGE
✓	✓	✓	✓	✓	German (no harmony)
	✓	✓	✓	✓	Sundanese
		✓	✓	✓	Johore Malay
			✓	✓	Epena Pedee
				✓	Applecross Gaelic

Table 1: Blockers in nasal harmony

(15) What about transparency?

(16) So far we have looked at nasal harmony patterns that involve contiguous strings of segments.

(17) Not all languages have such a pattern.

(18) Some languages show transparent obstruents:

a. Guaraní (Gregores & Suarez 1967; Walker 1999)
b. Barasano (Gomez-Imbert 1997),
c. Tuyuca (Barnes 1996)
d. Mọ̀bà (Ajíbóyè & Pulleyblank 2008)

(19) Example: Mọ̀bà nasal harmony (Ajíbóyè & Pulleyblank 2008)[1]

a. Distributions

ri	'drown'	r̃ĩ	'walk'
ru	'carry'	r̃ũ	'smell'

b. Alternations

VERB	NOUN		VERB	NOUN	
ɟɛ	u̲-ɟɛ	'eat'	r̃ĩ	ṵ̃-r̃ĩ	'walk'
fɛ	u̲-fɛ	'like'	ỹĩ	ṵ̃-ỹĩ	'praise'

(20) Obstruents show a different pattern: they can occur in oral and nasal roots (21).

(21) Transparent obstruents

uɟɛ	'bait'	ĩdũ	'bed bug'
ufɛ	'love'	ũgũ	'corner'
uko	'basket'	ĩsĩ	'worship'

(22) Table 2 shows the cross-linguistic typology of transparent segments in nasal harmony. Two patterns are attested.

[1] Tones are omitted.

VOWELS	GLIDES	LIQUIDS	FRICATIVES	OBS. STOPS	EXAMPLE LANGUAGE
			✓	✓	Guaraní, Mò̩bà
					Applecross

Table 2: Transparent segments in nasal harmony

(23) Crucially, no language shows transparent sonorants in nasal harmony (initiated by a vowel).

(24) Summary: The attested patterns of blocking differ from the attested patterns of transparency.

(25) Consequence: The accounts of blocking and transparency must be independent of one another.

2.2 RTR spreading

(26) We will discuss three spreading patterns that involve a single feature, [Retracted Tongue Root]:

a. Southern Palestinian Arabic has spreading to all segments.
b. Twi has vowel harmony that targets only vowels.
c. Wolof shows spreading to non-high vowels only.

(27) Recall that in Southern Palestinian Arabic (SPalestinian) pharyngealization spreads leftwards from an underlying trigger. The trigger of the alternation is an underlying pharyngealized segment, which targets all preceding root nodes within the same prosodic word.

(28) This pattern can be analyzed as [rtr] spreading (Davis 1995), which targets all segments. No segments are transparent.

(29) Emphasis spread in Southern Palestinian Arabic (Davis 1995:473–474)

BALLAAṢ	'thief'
ħAð̣ð̣	'luck'
ʔABSAṬ	'simpler'
BAAṢ	'bus'
MAJAṢṢAṢiʃ	'it didn't become solid'
Ṭiin-ak	'your mind'
ʕAṬʃaan	'thirsty'

(30) Twi exhibits tongue root vowel harmony. The tongue root position of affix vowels depend on root vowels. Lax affix vowels appear with lax root vowels, while tense affix vowels appear with tense root vowels. Consonants are transparent.

(31) Tongue root harmony in Twi (Berry 1957:127–128,130)

biri	'black'	o-biri	'3P-black'
		wu-biri	'2P-black'
bɪrɪ	'red'	ɔ-bɪrɪ	'3P-red'
		wʊ-bɪrɪ	'2P-black'
se	'say'	o-se	'3P-say'
		o-be-se	'3P-FUT-say'
sɛ	'resemble'	ɔ-sɛ	'3P-resemble'
		ɔ-bɛ-sɛ	'3P-FUT-resemble'
firi	'lend, borrow'	mi-be-firi-i	'1P-FUT-borrow-it'
fɪrɪ	'fail, miss'	mɪ-bɛ-fɪrɪ-ɪ	'1P-FUT-miss-it'

(32) Wolof (33) has RTR vowel harmony that targets only non-high vowels, ignoring not only consonants but also high vowels (Ka 1988/1994; Archangeli & Pulleyblank 1994; Kenstowicz 1994; Pulleyblank 1996; Krämer 2003).

(33) In (34-a) we see that root vowels determine the prefix vowel: tense root vowels are followed by tense suffix vowels, while lax root vowels are followed by lax suffix vowels. However, (34-b) shows that high vowels are not targeted and do not alternate. High vowels can be flanked by tense or lax vowels .

(34) Wolof tongue root harmony (Ka 1988/1994:13–16,31–35)

a.	door-e	'to hit with'	xɔɔl-ɛ	'to look with'
	reer-e	'to be lost in'	dɛm-ɛ	'to go with'
	gən-e	'to be better in'	xam-ɛ	'to know in'
	ɟeeg-o	'step'	mɛl-ɔ	'aspect'
	sofoor-əm	'his/her driver'	tɔɔl-am	'hie/her field'
	bəgg-ənte	'to love e.o.'	raw-antɛ	'to complete'
b.	wedd-i	'to straighten up'	lɛmm-i	'to unfold'
	ɲoox-it	'residue'	dɔg-it	'bit'
	dəkk-si	'to come and live'	wax-si	'to come and say'
	lett-u	'to braid hair'	sɛɛt-u	'to look in the mirror'
	sələm-u	'to wash face'	raxas-u	'to wash hands'
	deg-lu	'to listen'	tɛɛj-lu	'to act with caution'
c.	lettu-leen	'braid your hair!'	tɛkki-lɛɛn	'untie!'
	toxi-leen	'go and smoke!'	sɔppi-lɛɛn	'change!'
	gəstu-leen	'do research!'	watu-lɛɛn	'have a haircut!'
	seenu-woon	'tried to spot'	tɛɛru-wɔɔn	'welcomed
	sooxi-woon	'went and sank'	xɔlli-wɔɔn	'peeled'
	təri-woon	'went and slept'	raxasi-wɔɔn	'went and cleaned'

(35) Wolof can be analyzed as spreading of the feature [RTR], with transparent high vowels and consonants.

(36) Transparent segments in RTR spreading show an implicational pattern:

a. Transparent vowels imply transparent consonants.
b. Transparent non-high vowels imply transparent high vowels (and consonants).

(37) The following patterns are unattested:

a. RTR spreading targeting consonants, but not vowels.

b. RTR spreading targeting high vowels, but not all other segments.

(38) Transparency is restricted.

(39) Blocking does not exhibit the same pattern.

(40) Example 1: Emphasis spread in Southern Palestinian Arabic (Davis 1995:473−474)

a. Leftward unbounded

BALLAAṢ	‘thief’
ħAð̣ð̣	‘luck’
ʔABSAṬ	‘simpler’
BAAṢ	‘bus’
XAYYAAṬ	‘tailor’
NAʃAAṬ	‘energy’
TAMʃIIṬA	‘hair styling’

b. Rightward blocked by {i, y, j, ʃ}

ṢABAAħ	‘morning’
ʕAṬFAAL	‘children’
ṬUUB-AK	‘your blocks’
ṬWAAL	‘long.PL.’
ṢOOT-AK	‘your voice’
ṬEEF-AK	‘your sword’
Ṭiin-ak	‘your mind’
ʕAṬʃaan	‘thirsty’
MAJAṢṢAṢiʃ	‘it didn’t become solid’
ṢAyyaad	‘hunter’
ḌAjjat	‘type of noise.PL’

(41) The observation: {i, y, j, ʃ} are blockers, but not other segments.

(42) Another example comes from Yoruba (Bamgboṣe 1966, 1967; Awobuluyi 1967; Awobuluyi & Bamgboṣe 1967; Archangeli & Pulleyblank 1989, 1994; Pulleyblank 1996; Baković 2000; Krämer 2003, among many others) vowel harmony. The pattern resembles Wolof, with the difference that high vowels are blockers.

(43) Example 2: Yoruba vowel harmony

a. Mid vowels alternate (Awobuluyi 1967:2–4; Archangeli & Pulleyblank 1989: 177; Pulleyblank 1996:297,306)

ʃewe	‘publish a book’	o̲-ʃewe	‘publisher’
ɟowu	‘be jealous’	o̲-ɟowu	‘jealous person’
kɔsɛ	‘refuse’	ɔ̲-kɔsɛ	‘person who refuses’
ɟɛũ	‘eat’	ɔ̲-ɟɛũ	‘glutton’

b. High vowels block (Awobuluyi 1967:2–4; Archangeli & Pulleyblank 1989: 184,210,211; Pulleyblank 1996:306,311)

ewu̲rɛ	‘goat’	*ɛ̲wurɛ
elu̲bɔ	‘yam flour’	*ɛ̲lubɔ
oku̲rɔ	‘palm kernel’	*ɔ̲kurɔ
oru̲kɔ	‘name’	*ɔ̲rukɔ
eru̲pɛ	‘earth’	*ɛ̲rupɛ
odi̲dɛ	‘Grey Parrot’	*ɔ̲didɛ

(44) High vowels block spreading in Yoruba, yet consonants do not.

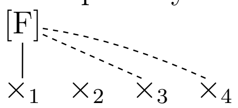
(45) There is no implicational pattern in RTR blocking.

(46) We can conclude that transparency and blocking are very different, and need separate accounts.

3 Representations

(47) Recall that in classic Autosegmental Phonology, transparency is represented as a gapped configuration (48).

(48) Transparency as a gapped configuration



(49) This representation implies that transparent segments are not affected by the spreading feature. However, there seems to be ample evidence to the contrary.

(50) Vowel harmony is grounded in the fact that one vowel can affect another even across a consonant (Öhman 1966; Recasens 1987; Fowler 1981; Magen 1997; Beddor et al. 2002; Modarresi et al. 2004; Benus 2005; Benus & Gafos 2007). In some languages these effects are phonologized.

(51) What about (transparent) consonants? The coarticulatory effect among vowels does affect consonants and transparent vowels.

(52) Boyce (1990)
...compares lip rounding of transparent non-labial consonants flanked by round vowels. She finds that Turkish speakers exhibit a plateau pattern in which lip rounding is retained in consonants. English speakers, on the other hand, show a decreased rounding on consonants, which can be characterized as a trough pattern. These differences suggest that English exhibits no rounding harmony (and thus has no transparent segments). Turkish, on the other hand, has rounding harmony in which consonants are phonetically affected by the spreading feature.

(53) Benus (2005), Benus & Gafos (2007)
...analyze Hungarian, which has backness harmony. Front vowels {i, e} are transparent to this process and can surface in a front or a back vowel word. It turns out that transparent vowels vary significantly depending on whether they are pronounced in a back vowel context or in a front vowel context. This suggests that vowels behave exactly like consonants in that they are phonetically affected if they are transparent.

(54) Beyond vowel harmony

a. Walker (1999) analyzes nasal harmony in Guaraní, which has transparent voiceless stops. While she does not find any evidence of nasal airflow during stops flanked by nasal segments (consistent with findings in Cohn 1990), she does find significant differences in voice onset time, which is longer in nasal contexts for labial and coronal stops.

b. Walker et al. (2008) look at tongue tip and blade movement during sibilant harmony in Kinyarwanda. They found that the fricatives displayed the greatest difference in the angle between tongue tip and blade, which suggests they are actual targets. Transparent non-coronals (and the flap) in retroflex contexts showed lower, but still significant differences between retroflex and non-retroflex contexts. Non-fricative coronals are blockers and show no variation. This is consistent with the model in which a continuous articulatory gesture extends over the transparent segments, even if such an effect is not perceptible.

(55) We can conclude that there is evidence that 'transparent' segments are also affected by spreading, at least in terms of phonetics.

(56) How does this relate to phonology?
There is a crucial difference between a target and a transparent segment. For example, while front target vowels become back after back vowels in Hungarian, transparent {i, e} do not become back vowels, even though their articulation is significantly affected.

(57) In response to these facts, perhaps the most obvious solution is to ignore the phonetic coarticulation and assume no spreading to transparent segments (classic Autosegmental Phonology).
One serious disadvantage of this approach is that it requires some sort of device to restrict skipping. Since the 1970s, much effort has been put into an account of how to restrict skipping that would fit the cross-linguistic data best (e.g. Howard 1972; Jensen 1974; Goldsmith 1976; Clements 1976/1980; Kiparsky 1981; Anderson & Ewen 1987; Archangeli & Pulleyblank 1987; Sagey 1990; Odden 1991, 1994; Halle 1995; Steriade 1995; Halle et al. 2000; Morén 2003; Nevins 2010).

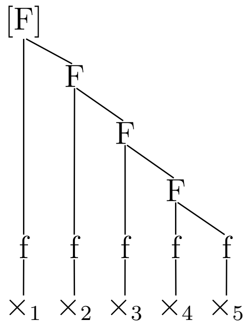
(58) An alternative solution is to say that spreading is always strictly local.
The disadvantage of this approach is it needs a separate explanation for why a particular feature is realized differently on some segments than on others. For example, nasality sometimes spreads to and across voiceless stops, which lack any independent cues of nasality. Much effort has been put into developing a realistic phonological model that would allow for a distinction between full targets and those targets lacking independent phonetic cues of the relevant feature (Itô et al. 1995; Padgett 1991, 1991/1995, Gafos 1996/1999; Walker 1998/2000; Ní Chiosáin & Padgett 1997, 2001; McCarthy 2004; Smolensky 2006).

(59) The proposal: Both approaches capture the right intuitions about locality in feature spreading, but neither gets it entirely right. The solution is to take both elements and join them in a new theory of feature spreading.

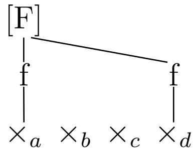
(60) a. Feature spreading always affects a contiguous string of segments.
b. At the same time, association between a feature and a target is formally different from association between a feature and a transparent segment.

(61) This builds on the fact that feature spreading is hierarchical. Some segments may contain heads of a feature, while others cannot. If so, then having another level of hierarchy is not at all surprising and directly follows from the current proposal.

(62) Recall the representation of spreading according to BDT below.

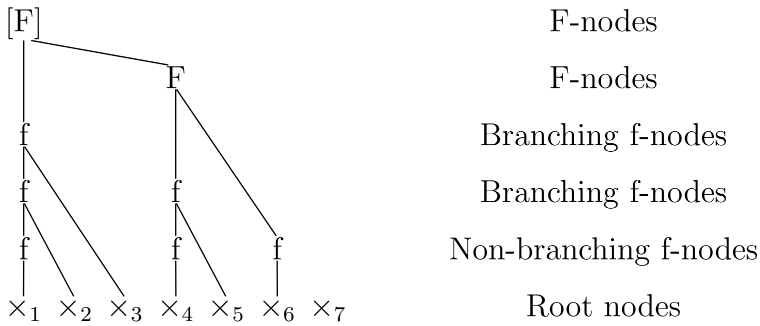
(63)


(64) Next, we see a representation with two transparent segments ($\times_b$, $\times_c$).

(65)


(66) Now, I introduce another layer of representations.

(67) Transparent segments are between the trigger and the two targets. Each of them is a dependent of a binary branching f-node, but is not associated with a non-branching f-node.

(68)


(69) The distinction between the trigger and non-final targets on the one hand and final targets on the other has been so far captured by the distinction between headed segments and non-headed segments.

(70) Two types of associations

a. Association
An $\times_i$ is associated with the feature [f], iff there is an association line between $\times_i$ and [f].

b. Full association
An $\times_i$ is fully associated with the feature [f], iff
there is an f-node of [f], such that
(i) f-node is associated with $\times_i$
and
(ii) f-node is not associated with any other $\times$.

c. Dependent association (or d-association)
An $\times_i$ is d-associated with the feature [f], iff
(i) the statement in (70-a) is true
and
(ii) the statement in (70-b) is not true.

(71) A simple extension of BDT allows us to distinguish transparent segments from triggers/targets purely representationally. This distinction is in that triggers and

targets are heads of f-nodes (and are linked to a non-branching f-node), while transparent segments are not (and are not linked to a non-branching f-node either).

(72) Extending BDT to transparent segments has a crucial phonological implication, namely that all spreading is always strictly local.

(73) No well-formed candidate will contain a segment not linked to a feature, while an autosegment is associated with a preceding root node and a subsequent root node at the same time.

(74) This is formalized in the Strict Locality Condition (75).

(75) Strict Locality Condition (SLC)
Let $\times_i < \times_j < \times_k$.
If $\times_i, \times_k$ are associated with the same autosegment [f], then $\times_j$ must also be associated with that [f].

(76) The Strict Locality Condition makes several robust phonological predictions.

a. Spreading to a target far from the trigger implies spreading to all intermediate targets.
b. When spreading to only one target is preferred, it will be to the one closest to the trigger.
c. Some segments may not be associated with a feature at all, and will effectively block spreading.

3.1 Constraints

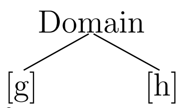
(77) The modified representations of transparent segments require some clarification regarding the constraints involved in assimilation.

3.1.1 Alignment

(78) Alignment constraints penalize triplets consisting of a spreading feature which precedes (or is preceded by) a targeted structure within a domain. This is captured by the general constraint template in (79).

(79) Featural alignment

a. *⟨Domain, [g], [h]⟩ /



b. Assign a violation mark for every triplet ⟨*Domain*, [g], [h]⟩, iff
the *Domain* is associated with [g] and [h]
and
[g] f-precedes [h].

(80) In this definition, f-precedence plays an important role (81).

(81) F-precedence ($\lhd$)
[g] $\lhd$ [h], iff
(i) $\exists \times_i$ associated with [g] but not with [h],
and
(ii) $\exists \times_j$ associated with [h] but not with [g],

and
(iii) $\times_i < \times_j$.

(82) In the context of the newly introduced distinction between transparent segments and targets, the definition of f-precedence needs to be revised such that it only includes full association of targets, but not dependent association of transparent segments. F-precedence of transparent segments cannot be established.[2]

(83) This means that alignment constraints can be satisfied only by full association.

(84) F-precedence limited to full association
[g] $\lhd$ [h], iff
(i) $\exists\times_i$ **fully** associated (70-b) with [g] but not with [h],
and
(ii) $\exists\times_j$ **fully** associated (70-b) with [h] but not with [g],
and
(iii) $\times_i < \times_j$.

(85) Note that f-precedence is formally:

a. neither symmetrical (if because if $G \lhd H$, then it may or may not be true that $H \lhd G$) nor asymmetrical (if $G \lhd H$, then it is not the case that $H \lhd G$ is always false)
b. neither transitive nor intransitive (if $G \lhd H$ and $H \lhd I$, then it may or may not be true that $G \lhd I$)
c. irreflexive ($G \lhd G$ can never be true)

(86) This differs greatly from precedence, which is asymmetrical, transitive, and irreflexive.

3.1.2 Faithfulness

(87) Strict Locality Condition in (75) which states that no root node can ever be skipped by a feature. This entails that transparent segments are also associated with the spreading feature, although in different terms than targets.

(88) There are at least two possible alternatives:

a. Faithfulness constraints can make reference only to full association. They remain agnostic with respect to d-association.
b. Faithfulness constraints can see both types of associations.

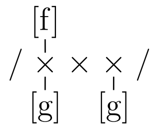
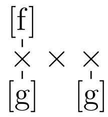
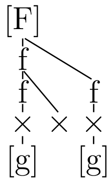
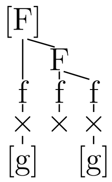
(89) The two models make very few different predictions, and I remain agnostic which of the two is correct.

(90) However, in what follows, I assume that faithfulness constraints see only full association. That is, they are violated by targets, but not by transparent segments.

(91) DEPLINK[f]
Let $\times_i$ be an input root node and $\times_o$ its output correspondent. Assign a violation mark, iff $\times_o$ is **fully** associated (70-b) with [f] and $\times_i$ is not.

[2] Some other modifications are also required. For details see Jurgec (2010).

(92) DepLink[f] evaluations

	DepLink[f]
a. 	
b. 	*
c. 	**

(93) The conclusions regarding DepLink[f] may be extended to other constraints that refer to association lines. In particular, MaxLink[f] is only satisfied if the full association in the input is preserved in the output.

3.1.3 Constraints on heads

(94) Transparent segments differ from targets in that they are not associated with a non-branching feature node. Instead, they are associated with a branching feature node that is headed by a trigger or a target. Such a representation of transparent segments has two implications for the constraints on heads.

(95) Transparent segments create additional feature domains (on preceding targets).

(96) Transparent segments are directly associated with a feature node that may be a headed element of a higher domain. This suggests that transparent segments can be themselves heads of a feature.

(97) Both full and dependent association are relevant when it comes to constraints on heads, which may be violated by transparent segments just as they are by targets.

(98) The upgraded BDT thus requires a more precise definition of heads.

(99) Feature head

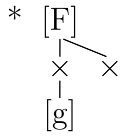
a. For every branching node of [f], there is exactly one *f-node* that is a Head of [f].

b. If *f-node*$_k$ is a Head of [f], all root nodes associated with *f-node*$_k$ are Heads of [f].

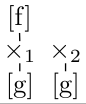
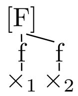
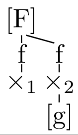
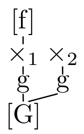
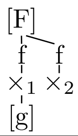
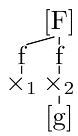
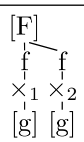
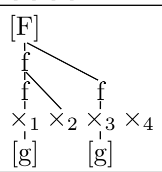
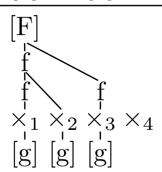
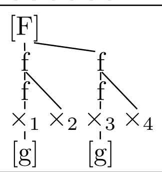
(100) This means that constraints on heads can be violated by transparent segments.

(101) *[F g]

a. Assign a violation mark for every root node ×, iff × is a Head of a feature [f] and × is associated with [g].

b. 

(102) *[F g] evaluations

		*[F g]
a.		
b.		
c.		
d.		
e.		$\times_1$
f.		$\times_2$
g.		$\times_1$
h.		$\times_1$
i.		$\times_1$ $\times_2$
j.		$\times_1$ $\times_3$

3.1.4 Feature co-occurrence constraints

(103) Feature co-occurrence constraints are well established in the literature (Stanley 43; Archangeli & Pulleyblank 1994; Walker 1998/2000). They penalize a combination of two (or more) features.

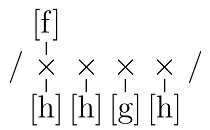
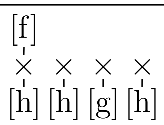
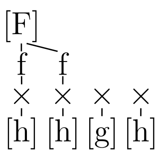
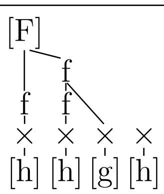
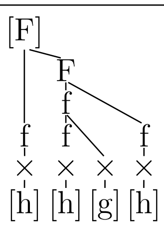
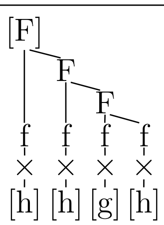
(104) These constraints are phonetically grounded. A feature co-occurrence constraint refers to features that are incompatible in terms of articulation, acoustics, or perception.

(105) Feature co-occurrence constraints are equally violated by full or dependent association. Both targets and transparent segments violate them.

(106) *[f g]
Assign a violation for every root node ×, iff × is associated with features [f] and [g].

Tableau (107) demonstrates the full effect of *[f g].

(107) *[f g] evaluations

	*[f g]
a. 	
b. 	
c. 	*
d. 	*
e. 	*

(108) We have now seen that both transparent segments and targets violate a feature co-occurrence constraint. In other words, both types of segments represent a marked structure, compared to unassociated segments (non-targets, blockers).

3.1.5 Summary

(109) Sensitivity of constraints to different types of association

Constraint	Example	Full association	D-association
Alignment	*ω[f,g]	✓	
Faithfulness	DEPLINK[f]	✓	(✓)
On heads	*[F g]	✓	✓
Feature co-occurrence	*[f g]	✓	✓

4 Analyses

4.1 RTR spreading

4.1.1 Transparency

(110) Recall the generalization regarding transparency:

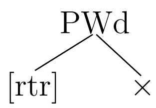
a. transparent vowels imply transparent consonants
b. transparent non-high vowels imply transparent high vowels (and consonants)

(111) From a different perspective, non-high vowels make the best targets, followed by high vowels, and consonants.

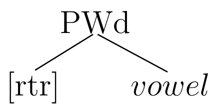
(112) In the current approach, targets are captured with alignment constraints. In particular, targets are determined by the targeted structure.

(113) At least three alignment constraints are required (114).

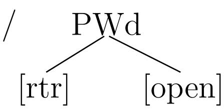
(114) a. *PWd[rtr, ×]
*⟨PWd, [rtr], ×⟩ /



b. *PWd[rtr, vowel]
*⟨PWd, [rtr], vowel⟩ /



c. *PWd[rtr, open][3]
*⟨PWd, [rtr], [open]⟩ /



(115) The relationship between the spreading feature and the targeted structure is not random. Each spreading feature comes with a set of targeted structures.

(116) When the spreading feature is [rtr], the targeted structures are {×, vowel, [open]}. This is phonetically and typologically grounded (Archangeli & Pulleyblank 1994).

(117) No matter how we rank these alignment constraints, we can never get unattested

[3]A privative feature common to all non-high vowels is [open] (cf. Clements & Hume 1995). Similar features have been proposed in other works that use privative features. For example, [A] is such a "feature" in Element Theory (Kaye et al. 1985, 1990; Harris & Lindsey 1995), while V-manner[open] is the equivalent in the Parallel Structures Model (Morén 2003, 2006). The privative feature [open] is directly parallel to the binary feature [−high].

patterns, such as transparent vowels, but not consonants. The unattested candidates are harmonically bounded (‘☜’).

(118) Factorial typology for RTR spreading

[r] / × e k i × /	*ø[rtr,open]	*ø[rtr,vow]	*ø[rtr,×]	DEPLINK[rtr]	*[rtr vow]	*[rtr high]	*[rtr open]	*[rtr cons]
a. × ɛ k i ×		i	k i	**	ɛ i	i	ɛ	k
b. ☜ × e k ɪ ×	e	e	e k	**	e ɪ	ɪ	e	k
c. ☜ × e K i ×	e	e i	e i	**	e i	i	e	K
d. × ɛ k ɪ ×			k	***	ɛ ɪ	ɪ	ɛ	k
e. ☜ × ɛ K i ×		i	i	***	ɛ i	i	ɛ	K
f. ☜ × e K ɪ ×	e	e	e	***	e ɪ	ɪ	e	K
g. × ɛ K ɪ ×				****	ɛ ɪ	ɪ	ɛ	K

(119) Feature co-occurrence constraints never prefer transparent segments.

4.1.2 Blocking

(120) What about blocking?

(121) Blocking is preferred by high ranked feature co-occurrence constraints.

(122) Recall that some segments block progressive emphasis spreads in SPalestinian, but not regressive.

(123) Blocking in SPalestinian progressive assimilation is enforced by feature co-occurrence constraint (124).

(124) *[rtr front]
Assign a violation for every root node ×, iff × is associated with features [rtr] and [front].

(125) This constraint is ranked below leftward alignment constraint (126).

(126) XAYYAAṬ 'tailor'

[r] / x a yy aa Ṭ /	*ω[×,rtr]	*[rtr front]	DepLink[rtr]
a. [r] x a yy aa Ṭ	*!***		
b. [R] r r x a yy AA Ṭ	*!**		*
c. ☞ [R] R R R r r r r r X A YY AA Ṭ		*	****

(127) At the same time, *[front rtr] is ranked above rightward alignment constraint, effectively blocking assimilation, as shown in (128).

(128) ṢAyyad 'hunter'

[r] / Ṣ a yy aa d /	*[rtr fr]	*ω[rtr],×	DepLink[rtr]	*[RTR fr]
a. [r] Ṣ a yy aa d		****!		
b. ☞ [R] r r Ṣ A yy aa d		***	*	
c. ☜ [R] r r r Ṣ A yy aa d	*!	***	*	
d. ☜ [R] r r r r Ṣ A yy aa d	*!	***	*	*
e. ☜ [R] r r r r r Ṣ A yy aa d	*!	***	*	*
f. [R] R r r r Ṣ A YY aa d	*!	**	**	
g. [R] R R r r r r r Ṣ A yy AA D	*!	*	***	*
h. [R] R R R r r r r r Ṣ A YY AA D	*!		****	*

4.2 Nasal harmony

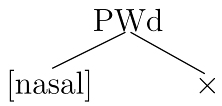
4.2.1 Transparency

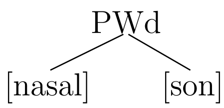
(129) Recall the generalizations regarding transparency: only obstruents can be transparent.

VOWELS	GLIDES	LIQUIDS	FRICATIVES	OBS. STOPS	EXAMPLE LANGUAGE
			✓	✓	Guaraní, Mọ̀bà
					Applecross

Table 3: Transparent segments in nasal harmony

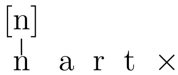
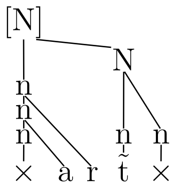
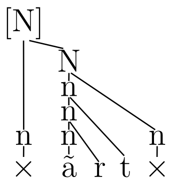
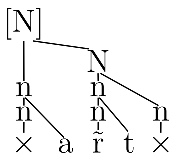
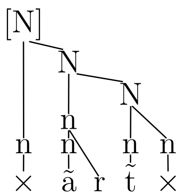
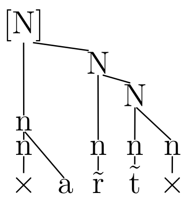
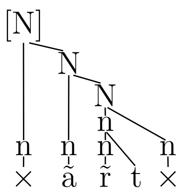
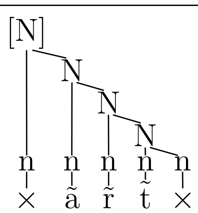
(130) Sonorants are never transparent. This can be ruled out by positing a restriction on what targeted structures are allowed with [nasal] as the spreading feature.

(131) a. *PWd[nasal, ×]
*⟨PWd, [nasal], ×⟩ /


b. *ω[nasal, sonorant]
*⟨PWd, [nasal], [son]⟩ /


(132) These alignment constraints cannot generate a pattern with transparent sonorants (133).

(133) Factorial typology in nasal harmony (without feature co-occurrence constraints)

[n] / × a r t × /	*ω[nas,son]	*ω[nas,×]	DepLink[nas]
a. 	a r	a r t ×	
b. ☞ 	a r	a r	**
c. ☞ 	r	r t	**
d. ☞ 	a	a t	**
e. ☞ 	r	r	***
f. ☞ 	a	a	***
g. 		t	***
h. 			****

4.2.2 Blocking

(134) What about blocking?

VOWELS	GLIDES	LIQUIDS	FRICATIVES	OBS. STOPS	EXAMPLE LANGUAGE
✓	✓	✓	✓	✓	German (no harmony)
	✓	✓	✓	✓	Sundanese
		✓	✓	✓	Johore Malay
			✓	✓	Epena Pedee
				✓	Applecross Gaelic

Table 4: Blockers in nasal harmony

(135) Recall that not all kinds of blocking exhibits implicational patterns. Nasal harmony, however, does.

(136) Segmental blocking can only be attributed to feature co-occurrence constraints. No other constraint in the current approach can enforce blocking by segments.

(137) The difference in segments' preference or aversion to [nasal] can only be attributed to several different feature co-occurrence constraints. Walker (1998/2000) proposes the universal fixed ranking in (138).

(138) Nasalized segment constraint hierarchy (Walker 1998/2000:36)
*NasObsStop ≡ *[+nas −cont −son] ≫
*NasFricative ≡ *[+nas +cont −son] ≫
*NasLiquid ≡ *[+nas +approx +cons] ≫
*NasGlide ≡ *[+nas +approx −cons −syll] ≫
*NasVowel ≡ *[+nas +approx −cons +syll] ≫
*NasSonStop ≡ *[+nas +son −cont]

(139) The fixed ranking in (139) has a simple effect: regardless of how other constraints are ranked, no output is possible such that, for example, glides block spreading but obstruents do not.

(140) /nazaja/ → [nã̃z̃ãja] can surface only with a dominant *NasGlide

/nazaja/	*NasFric	*NasGlide	*NasVowel	*ω[nas, ×]	DepLk[nas]
☞ nãz̃ãja	1		2	2	3
a. ∼ nazaja	L		L	$_5$ W	L
b. ∼ nãzaja	L		$_1$ L	$_4$ W	$_1$ L
c. ∼ nãz̃ãj̃ã	1	$_1$ W	$_3$ W	L	$_5$ W

(141) As we have seen, blocking in nasal harmony displays implicational properties, and one way of capturing this is by fixed ranking of feature co-occurrence constraints.[4]

[4]This generalization seems to hold in the vast majority of reported cases, there are a few exceptions. One of these is the Mọ̀bà dialect of Yoruba (Ajíbóyè & Pulleyblank 2008), in which nasality spreads to sonorants and high vowels, but not to non-high vowels. Other examples include blocking by schwa but not other vowels in Applecross (Ternes 1973), blocking by [r] but not [ɾ] in Epena Pedee (Harms 1985, 1994) and blocking by [ʁ] but not [r] in Urhobo (Kelly 1969).

5 Some further predictions

5.1 Icelandic

(142) Transparency is an inherently marked situation.

(143) This is because d-association incurs additional violation marks on some feature co-occurrence constraints and constraints on heads. At the same time, it does not fare better on any other markedness constraint.

(144) This has at least three consequences:

a. Transparency is avoided. If there are multiple identical targets available, but spreading to one is preferred, it will be the one closest to the trigger.
b. No transparent segments will be created after the final target.
c. Blockers are inherently more harmonic than transparent segments.

(145) The first and second point can be demonstrated on Icelandic. U-umlaut rounds /a/, turning it into [œ]. Such a derived [œ] is an icy target. A single target [œ] is preferred.

(146) Tableau (147) shows that the closest [œ] will be targeted. No subsequent segments will be transparent.

(147) japœnʏm 'Japanese.DAT.PL'

[rd] / j a p a n - ʏ m / [lo] [lo]	*[RD lo]	*ω[vow,rd]	DepLink[rd]
a. [rd] j a p a n ʏ m [lo] [lo]		**!	
b. ☞ [RD] rd rd rd j a p œ n ʏ m [lo] [lo]		*	*
c. ☜ [RD] rd rd rd rd rd j œ p a n ʏ m [lo] [lo]	*!	*	*
d. [RD] RD rd rd rd rd rd j œ p œ n ʏ m [lo] [lo]	*!		**
e. ☜ [RD] rd rd rd rd rd j a p œ n ʏ m [lo] [lo]	*!	*	*
f. ☣ [RD] rd rd j œ p a n ʏ m [lo] [lo]	Ruled	out by	SLC (75)!

5.2 Finnish

(148) In this section, I further look into the relationship between alignment and faithfulness constraints.

(149) In Finnish front/back harmony, targets do not form a closed natural class. No single feature is common to targets to the exclusion of all other segments.

(150) This means that *no single alignment constraint* can be used in an analysis of Finnish data.

(151) I instead propose that such patterns are attributed to the effect of multiple

alignment constraints. These constraints have the same spreading feature, but differ in targeted structures. This suggests that there are two natural classes of targets rather than a single one.

5.2.1 Data

(152) Finnish has backness harmony. This pattern is one of the best understood and most widely studied cases of vowel harmony (including Kiparsky 1973, 1981; Skousen 1972; Anderson 1975, 1980a,b; Campbell 1980, 1981; Halle & Vergnaud 1981; Goldsmith 1985; Välimaa-Blum 1987, 1999; Vago 1988; Ringen 1975/1988; Ringen & Heinämäki 1999; Baković 2000; Krämer 2002). In this section, I give a more detailed analysis, focusing on the relationship between transparent segments and targets.

(153) The Finnish vowel inventory contains eight vowels (154). This inventory is doubly asymmetrical. First, there are three front unrounded vowels, but only one back unrounded vowel. Second, the low vowels are all unrounded, while the non-low vowels are of two types—round and unrounded.[5]

(154) Finnish vowel inventory

		[rd]		[rd]	
	i	y		u	[closed]
	e	ø		o	
[low]	æ		ɑ		
			[back]		

(155) Front root vowels come with front suffix vowels, while back root vowels come with back suffix vowels; consonants are unaffected.

(156) Alternating vowels (Ringen 1975/1988:77; Ringen & Heinämäki 1999:305, 306; Krämer 2003:159, Ryan Johnson, p.c.)

pøytæ-næ	'table-ESSIVE'	poutɑ-nɑ	'fine weather-ESSIVE'
pyøræ-næ	'wheel-ESSIVE'	kuoro-nɑ	'choir-ESSIVE'
næh-køːn	'see-DIRECT.SG'	tul-koːn	'come-DIRECT.SG'
tyø-køːn	'work-DIRECT.SG'	tuo-koːn	'bring-DIRECT.SG'
næk-ø	'sight'	tul-o	'coming'
kæːnt-ø	'turn'	kaːt-o	'fall'

(157) Not discussed so far is the fact that the front non-low vowels {i, e} do not alternate. They always surface as front and do not interfere with spreading, as in (158). That is, non-low front vowels are transparent to vowel harmony.

(158) Transparent vowels (Ringen 1975/1988:77; Ringen & Heinämäki 1999:305; Krämer 2003:159)

kæde-lːæ	'hand-ADESSIVE'	tuoli-lːa	'chair-ADESSIVE'
næke-væt	'see-3PL'	tunte-vɑt	'feel-3PL'
kæte-næ	'hand-ESSIVE'	koti-nɑ	'home-ESSIVE'
hyv-i-næ	'good-PL-ESSIVE'	tsɑːri-nɑ	'czar-ESSIVE'

[5] Note that the features used are fairly standard, with the exception of [closed]. Here, this feature is the privative equivalent of [−low]. Other works use similarly named features (Clements 1985; Sagey 1990; Odden 1991; Clements & Hume 1995; Morén 2003, 2006). The feature [close] is also directly parallel to the feature [open], which is the privative equivalent of [−high] and has been used extensively throughout this thesis.

(159) The same is true for a string of several front non-low unrounded vowels {i, e}. In (160) we see three roots followed by a string of suffixes, of which only the final alternates. The intermediate suffixes containing {i, e} are not affected. In these examples, the final suffix always agrees in backness with the root vowel other than {i, e}.[6]

(160) Multiple transparent vowels (Krämer 2003:166)

ui-dɑ	'to swim'	ui-ske-nt-ele-mi-se-ni-ko	'my swimming around?'
syø-dæ	'to eat'	syø-ske-nt-ele-mi-se-ni-kø	'my constant eating?'
teh-dæ	'to do'	teː-ske-nt-ele-mi-se-ni-kø	'my pretending?'

(161) To summarize, Finnish vowel harmony can be characterized as follows. First, front vowels alternate with back vowels. Second, front non-low unrounded vowels {i, e} never alternate and do not interfere with spreading, which suggests they are transparent.

5.2.2 Analysis

(162) I analyze Finnish as [back] harmony.

(163) The faithfulness constraint against spreading the feature [back] is DepLink[back].

(164) This constraint is outranked by the alignment constraint. Recall the first class in which I analyzed the pattern using the constraint ∗ω[back,vowel].

(165) However, given the fact that {i, e} are transparent to vowel harmony, a revision is required. This is because transparency cannot be attributed to any other constraint.

(166) Transparency is a marked configuration. No constraint prefers transparency (to blocking or being a target).

(167) Transparency informs the analysis in terms of the targeted structure of the alignment constraint, which should be the complement of the set of all transparent segments.

(168) In Finnish, all consonants and the two vowels {i, e} are transparent.

(169) Under no universal feature theory can these segments be grouped into a natural class to the exclusion of all other segments.[7]

(170) What I propose is that the pattern in Finnish is attributed to two alignment constraints. Both have the spreading feature [back], the domain (PWd) and the f-precedence relations in common (the spreading feature f-precedes the targeted structure).

(171) They differ in the targeted structure. One targets [low] vowels, while the other targets [round] vowels.

[6] A noted exception to this generalization are the patterns found in some loanwords ending on two or more {i, e}. These roots tend to take front suffixes, even when back ones are expected (see Välimaa-Blum 1999; Ringen & Heinämäki 1999 for details). I will not attempt to analyze these exceptional patterns.

[7] Substance-free phonology can capture these patterns, since there is no a priori restriction on feature combinations (Morén 2003, 2006; Youssef 2010, to appear; Blaho 2008; Samuels 2009). This approach has no cross-linguistically valid strategy to exclude a feature that would be common to all consonants and {i, e}, but not to other vowels.

(172) If we look at the Finnish vowel inventory in (154) that the sets of low vowels {æ, ɑ} and round vowels {y, ø, u, o} are disjunctive. Hence the two alignment constraints that refer to these two classes will not interact, which means that we do not know which outranks the other.

(173) The relevant alignment constraints are *ω[back,round] and *ω[back,low]. The effect of the ranking is shown in (174).

(174) pɑri-nɑ-si-ko 'as your partner?' (Kiparsky 1981:10)

[b] / p ɑ r i - n æ - s i - k ø / [l] [l] [r]	*ω[bk,rd]	*ω[bk,lo]	DepLk[bk]
a. [b] p ɑ r i n æ s i k ø [l] [l] [r]	*(!)	*(!)	
b. [B] b b b b b p ɑ r i n ɑ s i k ø [l] [l] [r]	*!		*
c. [B] b b b b b b b b b p ɑ r i n æ s i k o [l] [l] [r]		*!	*
d. ☞ [B] B b b b b b b b b b p ɑ r i n ɑ s i k o [l] [l] [r]			**
e. [B] B B B b b b b b b b b b p ɑ r ɯ n ɑ s ɯ k o [l] [l] [r]			***!*

(175) To conclude, Finnish vowel harmony is slightly more complex then the previ-

ously discussed cases, because the pattern involves two alignment constraints that differ only in their targeted structures.

(176) The targeted structures of these alignment constraints are inherently connected to transparent segments. Consider the alignment constraints that outrank the relevant DepLink[f] constraint, and the sets of segments containing the targeted structures of these constraints. Formally speaking, transparent segments are defined as the intersection of complements of these sets (177).

(177) The connection between transparency, alignment and DepLink[f]
Let $\mathbb{C}_a$, $\mathbb{C}_b$ ... $\mathbb{C}_n$ be alignment constraints of the type **Domain*[f,*x*].
Let A be the set of segments containing the targeted structure of $\mathbb{C}_a$.
Let B be the set of segments containing the targeted structure of $\mathbb{C}_b$.
...
Iff $\{\mathbb{C}_a,\ \mathbb{C}_b \ldots \mathbb{C}_n\} \gg$ DepLink[f], then the set of transparent segments $T = \neg A \cap \neg B \cap \ldots \cap \neg N$

(178) One consequence of this analysis is that it does not require any notion of contrast.

(179) The fact that Finnish lacks back correspondents of {i, e} appears purely accidental. There are other languages that provide support for such a conclusion.

a. C'Lela has lowering harmony that targets only the final vowel, skipping all other (even identical) targets (Dettweiler 2000; Pulleyblank 2002; Archangeli & Pulleyblank 2007; Michel to appear).

b. In Khalkha Mongolian (to be analyzed next time), [i] is transparent to rounding (and backness) harmony, even though the language allows [u] in other positions.

(180) Given these patterns, we have to conclude that contrast is not essential for a theory of transparency, despite the fact that it appears to be a possible alternative for some cases of assimilation.

6 Conclusions

(181) Transparent segments are fundamentally different from blockers and targets.

(182) Transparent segments are d-associated with the spreading feature, while blockers are not associated with the feature.

(183) Transparency is a marked configuration. No constraint favors only transparent segments.

(184) Not all transparent segments are equally marked.

(185) Transparency does not rely on contrast.

References

Ajíbóyè, Oládiípò & Douglas Pulleyblank (2008). Mòbà nasal harmony. Ms., University of Lagos and University of British Columbia.

Anderson, John Mathieson & Colin J. Ewen (1987). *Principles of Dependency Phonology*. Cambridge: Cambridge University Press.

Anderson, Lloyd B. (1975). *Phonetic and Psychological Explanations for Vowel Harmony, Especially in Finnish*. Ph.D. dissertation, University of Chicago, Chicago.

Anderson, Lloyd B. (1980a). Using asymmetrical and gradient data in the study of vowel harmony. In Robert Vago (ed.) *Issues in vowel harmony*, Amsterdam: John Benjamins. 271–340.

Anderson, Stephen R. (1980b). Problems and perspectives in the description of vowel harmony. In Robert Vago (ed.) *Issues in vowel harmony*, Amsterdam: John Benjamins. 1–48.

Archangeli, Diana & Douglas Pulleyblank (1987). Minimal and maximal rules: Effects of tier scansion. In *Proceedings of NELS 17*, Amherst: GLSA, University of Massachusetts. 16–35.

Archangeli, Diana & Douglas Pulleyblank (1989). Yoruba vowel harmony. *Linguistic Inquiry* **20**. 173–217.

Archangeli, Diana & Douglas Pulleyblank (1994). *Grounded Phonology*. Cambridge, MA: MIT Press.

Archangeli, Diana & Douglas Pulleyblank (2007). Harmony. In Paul de Lacy (ed.) *The Cambridge Handbook of Phonology*, Cambridge: Cambridge University Press. 353–378.

Awobuluyi, A. Oladele (1967). Vowel and consonant harmony in Yoruba. *Journal of African Languages* **6**. 1–8.

Awobuluyi, A. Oladele & Ayọ Bamgbọṣe (1967). Two views of vowel harmony in Yoruba. *Journal of African Languages* **6**. 274–277.

Baković, Eric (2000). *Harmony, Dominance, and Control*. Ph.D. dissertation, Rutgers University. Available on Rutgers Optimality Archive, ROA 360, http://roa.rutgers.edu.

Bamgbọṣe, Ayọ (1966). *A Grammar of Yoruba*. Cambridge: Cambridge University Press.

Bamgbọṣe, Ayọ (1967). Vowel harmony in Yoruba. *Journal of African Languages* **6**. 268–273.

Barnes, Janet (1996). Autosegments with three-way contrasts in Tuyuca. *International Journal of American Linguistics* **62**. 31–58.

Beddor, Patrice Speeter, James D. Harnsberger & Stephanie Lindemann (2002). Language-specific patterns of vowel-to-vowel coarticulation: acoustic structures and their perceptual correlates. *Journal of Phonetics* **30**. 591–627.

Benus, Stefan (2005). *Dynamics amd Transparency in Vowel Harmony*. Ph.D. dissertation, New York University, New York.

Benus, Stefan & Adamantios I. Gafos (2007). Articulatory characteristics of Hungarian 'transparent' vowels. *Journal of Phonetics* **35**. 271–300.

Berry, J. (1957). Vowel harmony in Twi. *Bulletin of the School of Oriental and African Studies, University of London* **19**. 124–130.

Blaho, Sylvia (2008). *The syntax of phonology: A radically substance-free approach*. Ph.D. dissertation, University of Tromsø, Tromsø.

Boyce, Suzanne E. (1990). Coarticulatory organization for lip rounding in Turkish and English. *Journal of the Acoustical Society of America* **88**. 2584–2595.

Campbell, Lyle (1980). The psychological and sociological reality of Finnish vowel harmony. In Robert Vago (ed.) *Issues in vowel harmony*, Amsterdam: John Benjamins. 245–270.

Campbell, Lyle (1981). Generative phonology vs. Finnish phonology: Retrospect and prospect. In D. L. Goyvaerts (ed.) *Phonology in the 1980's*, Ghent: E. Story-Scientia. 147–182.

Clements, George N. (1976/1980). *Vowel Harmony in Nonlinear Generative Phonology*.

Bloomington: Indiana University Linguistics Club.
Clements, George N. (1985). The geometry of phonological features. *Phonology* **2**. 225–252.
Clements, George N. & Elizabeth V. Hume (1995). The internal organization of speech sounds. In John A. Goldsmith (ed.) *The Handbook of Phonological Theory*, Blackwell. 245–306.
Cohn, Abigail C. (1990). *Phonetic and Phonological Rules of Nasalization*. Ph.D. dissertation, University of California, Los Angeles, Los Angeles.
Cohn, Abigail C. (1993). The status of nasalized continuants. In Marie K. Huffman & Rena A. Krakow (eds.) *Phonetics and Phonology 2: Nasals, Nasalization, and the Velum*, San Diego, CA: Academic Press. 329–367.
Davis, Stuart (1995). Emphasis spreading in Arabic and Grounded Phonology. *Linguistic Inquiry* **26**. 465–498.
Dettweiler, Stephen H. (2000). Vowel harmony and neutral vowels in c'Lela. *Journal of West African Languages* **18**. 3–18.
Fowler, Carol A. (1981). Production and perception of coarticulation among stressed and unstressed vowels. *Journal of Speech and Hearing Research* **24**. 127–139.
Gafos, Adamantios I. (1996/1999). *The articulatory basis of locality in phonology*. New York: Garland.
Goldsmith, John A. (1976). *Autosegmental Phonology*. Ph.D. dissertation, Massachusetts Institute of Technology, Cambridge.
Goldsmith, John A. (1985). Vowel harmony in Khalkha Mongolian, Yaka, Finnish and Hungarian. *Phonology Yearbook* **2**. 253–275.
Gomez-Imbert, Elsa (1997). *Morphologie et phonologie Barasana: approche non-linéaire*. Ph.D. dissertation, Université de Paris 8, Paris.
Gregores, Emma & Jorge A. Suarez (1967). *A description of colloquial Guaraní*. The Hague: Mouton de Gruyter.
Halle, Morris (1995). Feature geometry and feature spreading. *Linguistic Inquiry* **16**. 1–46.
Halle, Morris, Bert Vaux & Andrew Wolfe (2000). On feature spreading and the representation of place of articulation. *Linguistic Inquiry* **31**. 387–444.
Halle, Morris & Jean-Roger Vergnaud (1981). Harmony processes. In Wolfgang Klein & Williem Levelt (eds.) *Crossing the boundaries in linguistics: Studies presented to Manfred Bierwisch*, Dordrecht: Reidel. 1–22.
Harms, Phillip Lee (1985). Epena Pedee (Saija) nasalization. In Ruth Brend (ed.) *From Phonology to Discourse: Studies in Six Columbian Languages*, Dallas, TX: Summer Institute of Linguistics. 13–18.
Harms, Phillip Lee (1994). *Epena Pedee Syntax*. Arlington, TX: The Summer Institute of Linguistics and The University of Texas at Arlington.
Harris, John & Geoff Lindsey (1995). The elements of phonological representation. In Jacques Durand & Francis Katamba (eds.) *Frontiers of Phonology: Atoms, Structures, Derivations*, London, New York: Longman. 34–79.
Howard, Irwin (1972). *A Directional Theory of Rule Application in Phonology*. Ph.D. dissertation, Massachusetts Institute of Technology, Cambridge.
Itô, Junko, Armin Mester & Jaye Padgett (1995). Licensing and underspecification in Optimality Theory. *Linguistic Inquiry* **26**. 571–631.
Jensen, John T. (1974). A constraint on variables in phonology. *Language* **50**. 675–686.
Jurgec, Peter (2010). *Feature Spreading 2.0: A Unified Theory of Assimilation*. Ph.D.

dissertation, University of Tromsø, Tromsø.

Ka, Omar (1988/1994). *Wolof Phonology and Morphology*. Lanham, MD: University Press of America.

Kaye, Jonathan, Jean Lowenstamm & Jean-Roger Vergnaud (1985). The internal structure of phonological elements: a theory of charm and goverment. *Phonology Yearbook* **2**. 305–328.

Kaye, Jonathan, Jean Lowenstamm & Jean-Roger Vergnaud (1990). Constituent structure and government in phonology. *Phonology* **7**. 193–232.

Kelly, John (1969). Urhobo. In Elizabeth Dunstan (ed.) *Twelve Nigerian languages*, New York: Africana Publishing Corporation. 153–161.

Kenstowicz, Michael (1994). *Phonology in Generative Grammar*. Malden, MA: Blackwell.

Kiparsky, Paul (1973). Phonological representations. In Osamu Fujimura (ed.) *Three Dimensions of Linguistic Theory*, Tokyo: TEC. 1–136.

Kiparsky, Paul (1981). Vowel harmony. Ms. Massachusetts Institute of Technology.

Krämer, Martin (2002). Local constraint conjunction and neutral vowels in Finnish harmony. In Brunger Karen (ed.) *Belfast Working Papers in Language and Linguistics, vol. 15*, Belfast: University of Ulster. 38–64.

Krämer, Martin (2003). *Vowel Harmony and Correspondence Theory*. Berlin and New York: Mouton de Gruyter.

Magen, Harriet S. (1997). The extent of vowel-to-vowel coarticulation in English. *Journal of Phonetics* **25**. 187–205.

McCarthy, John J. (2004). Headed spans and autosegmental spreading. Ms., University of Massachusetts Amherst. Available on Rutgers Optimality Archive, ROA 685, http://roa.rutgers.edu.

Michel, Dan (to appear). Positional transparency in c'Lela. In *Chicago Linguistic Society (CLS) 45*, Chicago: Chicago Linguistic Society.

Modarresi, Golnaz, Harvey Sussman, Björn Lindblom & Elizabeth Burlingame (2004). An acoustic analysis of the bidirectionality of coarticulation in VCV utterances. *Journal of Phonetics* **32**. 291–312.

Morén, Bruce (2003). The parallel structures model of feature geometry. In J. Brugman & A. Rhiel (eds.) *Working Papers of the Cornell Phonetics Laboratory*, Cornell University, vol. 15. 194–270.

Morén, Bruce (2006). Consonant-vowel interactions in Serbian: Features, representations and constraint interactions. *Lingua* **116**. 1198–1244.

Nevins, Andrew (2010). *Locality in Vowel Harmony*. Cambridge, MA: MIT Press.

Ní Chiosáin, Máire & Jaye Padgett (1997). Markedness, segment realization, and locality of spreading. In *Report no. LRC-97-01, Linguistics Research Center*, Santa Cruz: University of California, Santa Cruz. Available on Rutgers Optimality Archive, ROA 188, http://roa.rutgers.edu.

Ní Chiosáin, Máire & Jaye Padgett (2001). Markedness, segment realization, and locality of spreading. In Linda Lombardi (ed.) *Segmental Phonology in Optimality Theory: Constraints and Representations*, Santa Cruz: Cambridge University Press. 118–156.

Odden, David (1991). Vowel geometry. *Phonology* **8**. 261–289.

Odden, David (1994). Adjacency paramaters in phonology. *Language* **70**. 289–330.

Öhman, S. E. G. (1966). Coarticulation in VCV utterances: Spectrographic measurements. *Journal of the Acoustical Society of America* **39**. 151–168.

Onn, Farid M. (1980). *Aspects of Malay Phonology and Morphology: A Generative Approach*. Ph.D. dissertation, Universiti Kebangsaan Malaysia, Bangi.

Padgett, Jaye (1991). *Stricture in Feature Geometry*. Ph.D. dissertation, University of Massachusett, Amherst.

Padgett, Jaye (1991/1995). *Stricture in Feature Geometry*. Stanford, CA: CSLI Publications.

Piggott, Glyne (2000). Against featural alignment. *Journal of Linguistics* **36**. 85–129.

Piggott, Glyne (2003). Theoretical implications of segment neturality in nasal harmony. *Phonology* **20**. 375–424.

Piggott, Glyne & Harry van der Hulst (1997). Locality and the nature of nasal harmony. *Lingua* **103**. 85–112.

Pulleyblank, Douglas (1996). Neutral vowels in Optimality Theory: A comparison of Yoruba and Wolof. *Canadian Journal of Linguistics* **41**. 295–347.

Pulleyblank, Douglas (2002). Harmony drivers: No disagreement allowed. In *Proceedings of the 28th Annual meeting of the Berkeley Linguistics Society*. 249–267.

Recasens, Daniel (1987). An acoustic analysis of V-to-C and V-to-V coarticulatory effects in Catalan and Spanish VCV sequence. *Journal of Phonetics* **15**. 299–312.

Ringen, Catherine (1975/1988). *Vowel harmony: Theoretical Implications*. New York: Garland.

Ringen, Catherine & Orvokki Heinämäki (1999). Variation in Finnish vowel harmony: An OT account. *Natural Language and Linguistic Theory* **17**. 303–337.

Robins, R. H. (1957). Vowel nasality in Sundanese, a phonological and grammatical study. In *Studies in linguistic analysis*, Oxford: Blackwell. 87–103.

Sagey, Elizabeth (1990). *The Representation of Features in Non-Linear Phonology: The Articulator Node Hierarchy*. New York and London: Garland.

Samuels, Bridget (2009). *The Structure of Phonological Theory*. Ph.D. dissertation, Harvard University, Cambridge, MA. Available on Lingbuzz, 863, http://ling.auf.net.

Schourup, Lawrence (1973). A cross-linguistic study of vowel nasalization. In *Working Papers in Linguistics*, Columbus, OH: Ohio State University, vol. 15. 190–221.

Skousen, Royal (1972). Finnish vowel harmony: rules and conditions. In Michael Kenstowicz & Charles Kisseberth (eds.) *Issues in phonological theory*, The Hague: Mouton de Gruyter. 118–129.

Smolensky, Paul (2006). Optionality in phonology II: harmonic completeness, local constraint conjunction, and feature domain markedness. In *The Harmonic Mind: From Neural Computation to Optimality-Theoretic Grammar*, Cambridge, MA: MIT Press. 27–160.

Stanley, Richard (43). Redundancy rules in phonology. *Language* **2**. 393–436.

Steriade, Donca (1995). Underspecification and markedness. In John A. Goldsmith (ed.) *The Handbook of Phonological Theory*, Oxford: Blackwell. 114–174.

Ternes, Elmar (1973). *The Phonemic Analysis of Scottish Gaelic: Based on the Dialect of Applecross, Ross-shire*. Hamburg: Helmut Buske Verlag.

Vago, Robert (1988). Vowel harmony in Finnish word games. In Harry van der Hulst & Norval Smith (eds.) *Features, Segmental Structure and Harmony Processes (Part II)*, Dordrecht: Foris. 185–205.

Välimaa-Blum, Ritta (1987). Finnish vowel harmony as a prescriptive and descriptive rule: An autosegmental account. In Fred Marshall, Ann Miller & Zhen-Sheng Zhang (eds.) *Eastern States Conference on Linguistics (ESCOL '86)*, Columbus, OH: Ohio State University. 511–522.

Välimaa-Blum, Ritta (1999). A feature-geometric description of Finnish vowel harmony covering both loans and native words. *Lingua* **108**. 247–268.

Walker, Rachel (1998/2000). *Nasalization, Neutral Segments, and Opacity Effects*. New York: Garland.

Walker, Rachel (1999). Guaraní voiceless stops in oral versus nasal contexts: an acoustical study. *Journal of the International Phonetic Association* **29**. 63–94.

Walker, Rachel (2003). Reinterpreting transparency in nasal harmony. In Jeroen van de Weijer, Vincent J. van Heuven & Harry van der Hulst (eds.) *The Phonological Spectrum 1: Segmental Structure*, Amsterdam: John Benjamins. 34–72.

Walker, Rachel, Dani Byrd & Fidèle Mpiranya (2008). An articulatory view of Kinyarwanda coronal harmony. *Phonology* **25**. 499–535.

Youssef, Islam (2010). Against underlying mid vowels in Cairene Arabic. *Zeitschrift für Arabische Linguistik* **52**. 5–38.

Youssef, Islam (to appear). Laryngeal assimilation in Buchan Scots. *Journal of English Language and Linguistics* **14**.