Vowel Harmony as Agreement by Correspondence

Russell Rhodes
UC Berkeley

1 Introduction

Initially, it was believed that blocking effects[1] simply could not be modeled with Agreement by Correspondence (ABC) (Hansson 2001; Rose & Walker 2004). Hansson, in particular, lays out this assumption very clearly: "Intervening segments do not themselves enter into the agreement relation holding between the trigger-target pair, and therefore they must be irrelevant to that relation: they *cannot* be opaque" (237, his emphasis). The model's assumed inability to account for opaque segments was seen as a positive with respect to accounting for consonant harmony[2] because blocking effects are extremely rare in consonant harmony systems[3]. However, since opaque segments are common in vowel harmony systems, it was unclear how applicable ABC would be to vowel harmony. In spite of this, Rose & Walker are optimistic about the possibility of analyzing at least some vowel harmony systems as ABC:

> Vowel harmony presents a promising area in which to explore further applications of the ABC approach ... [C]ertain cases of rounding harmony limit the participant segments to ones that are similar, specifically, they match in height. In addition, many patterns of vowel harmony show nonlocal interactions across intervening transparent vowels, suggesting that ABC might be at work ... The suitability of an ABC approach for such patterns would need to be assessed in the context of individual case studies. (520)

The current paper, presents two such case studies in an effort to assess the suitability of the ABC approach, not just for these two systems, but for vowel harmony more generally.

After an introduction to ABC and a review of the history of blocking and ABC in §2, §3 contains the case study of Khalkha Mongolian rounding harmony. Khalkha offers a particularly good test case because it is exactly the type of system that Rose & Walker suggest could be analyzed as ABC. Rounding harmony is restricted to vowels agreeing in height and shows nonlocal interactions across intervening transparent vowels. Additionally, Khalkha presents a challenge because it involves a

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[1]When I say blocking effects, I am referring to any situation where the presence of a segment between a trigger of harmony and a potential target of harmony prevents that potential target from agreeing with the trigger for the harmony feature. I will be using the term opacity interchangeably with blocking effects and I will refer to the segment that blocks harmony as an opaque segment.

[2]Consonant harmony is also sometimes referred to as Long Distance Consonant Agreement.

[3]There are only two attested cases of blocking in consonant harmony systems: Ineseño Chumash sibilant harmony (Poser 1982; Applegate 1972) and Kinyarwanda coronal harmony (Walker & Mpiranya 2006). Though, it is worth noting that, although Hansson (2001:Ch. 5) demonstrated that the blocking in Chumash sibilant harmony can be accounted for using ABC augmented with targeted constraints (Wilson 2000, 2001), the case of Kinyarwanda coronal harmony is more problematic for ABC. In fact, Walker & Mpiranya (2006) analyze the harmony not as ABC, but as featural spreading.

case of opacity that Hansson (2007) has specifically claimed cannot be accounted for with the basic model of ABC.

The second study is of the well known case of Finnish palatal harmony and is presented in §4. Unlike Khalkha rounding harmony, palatal harmony in Finnish is not restricted to any particular subset of vowels, so it is perhaps a less obviously appropriate test case for ABC. However, palatal harmony does involve nonlocal interaction across intervening transparent vowels and similar cases of transparency have proven challenging for previous Optimality Theory (OT; Prince & Smolensky 1993/2002) analyses of vowel harmony, requiring new theoretical machinery (see e.g., Baković & Wilson 2000; Krämer 2003). Given ABC's ability to handle even extreme cases of transparency, it appears to offer a promising possible analysis of the system.

In each case study, I will show that, in spite of apparent challenges, it is possible to account for the relevant vowel harmony system, including transparent and opaque segments, without addition to or modification of the basic ABC model. Given the considerable differences between the two harmony systems and the challenges they pose, I take the fact that they can be accounted for with the basic ABC model to indicate that the approach has even greater potential to account for vowel harmony than Rose & Walker's quote would suggest. Since ABC is able to handle difficult cases of opacity, like that found in Khalkha, and transparency, like the one found in Finnish, the model might be all that is needed to account for vowel harmony, as well as consonant harmony. Before concluding this it is important to address previous arguments that the coverage of ABC should be limited to consonant harmony (Hansson 2001) or, even more specifically, to cases where consonants cooccurring in a root are required to be identical (Gallagher to appear). These are discussed in §5. Finally, in §6 I offer some brief conclusions.

2   ABC Preliminaries

In this paper, I will be assuming the basic model of ABC as laid out in Rose & Walker (2004) and Hansson (2001), which I introduce in §2.1. In §2.2, I offer a brief discussion of ABC and blocking.

2.1   Introduction to ABC

A variety of recent research has found that more similar segments in an output string are more likely to interact than segments that are less closely related. In their survey of consonant harmony systems, Rose & Walker found that "the interacting segments bear a high degree of SIMILARITY" [their emphasis] (484), where similarity is defined in terms of shared phonological features, such as [sonorant] or [continuant]. Frisch *et al.* (2004) looked at Arabic consonantal roots and found that consonants are less likely to co-occur if they are similar to each other. Comparing the observed number of co-occurrences of pairs of consonants to the number of co-occurrences that would be expected if the combination of consonants were random, they found that homorganic consonants are far less likely to co-occur than would be expected by random combination. Additionally, they find that a pair of consonants is even less likely to co-occur if, in addition to sharing place of articulation, both are stops or both are fricatives. ABC, like its precursor Aggressive Reduplication (Zuraw 2002), is an attempt to formalize this insight that similar segments tend to interact. In particular, ABC and Aggressive Reduplication are concerned with the tendency for already similar segments to become even more similar.

Under ABC, agreement between nonadjacent segments, as in vowel harmony, is regulated by

two distinct families of constraints: CORR-SS and IDENT-SS constraints. CORR-SS constraints compel segments within an output string to correspond. The relationship between corresponding output segments is analogous to the relationship between corresponding input and output segments or the relationship between corresponding segments in a base and a reduplicant in Base Reduplicant Correspondence Theory (McCarthy & Prince 1995). That is to say that the correspondence relationship offers a way for output segments to be required to be faithful to each other. The particular way that corresponding output segments are required to be faithful to one another in harmony is through IDENT-SS constraints. IDENT-SS constraints compel corresponding segments within an output string to agree for a particular feature. For example, IDENT-CC(NAS) requires that corresponding output segments agree for the feature [nasal].

ABC incorporates the insight that similar segments tend to interact via the CORR-SS contraints, which only compel segments that are sufficiently similar to correspond. What constitutes sufficiently similar depends on the specific constraints. For example, CORR-KT only compels stops with the same voicing to correspond, while CORR-KD compels all stops to correspond. Additionally, CORR-SS constraints are in a fixed similarity-based hierarchy. This means that CORR-SS constraints compelling more similar segments to correspond always outrank CORR-SS constraints that compel less similar segments to correspond. For example, CORR-KT always outranks CORR-KD.

A brief sample analysis based on Walker's (2000) analysis of Ngbaka voicing harmony should make it a bit clearer how ABC works. In Ngbaka, homorganic oral stops are required to agree in voicing, while heterorganic oral stops are not. Four constraints are needed to account for this pattern. First, a constraint that compels oral stops with the same place of articulation to correspond is needed. The relevant constraint is CORR-TD, which is defined in (1) (based on Rose & Walker 2004, 491).

(1) CORR-TD – Let S be an output string of segments and let X and Y be segments specified [-son, -cont, α Place]. X and Y correspond if X, Y $\in$ S.

CORR-TD is violated if a pair of homorganic oral stops fails to correspond.

The second constraint needed to account for the Ngbaka pattern is a constraint that compels all oral stops to correspond. The relevant constraint is CORR-KD, which is defined in (2).

(2) CORR-KD – Let S be an output string of segments and let X and Y be segments specified [-son, -cont]. X and Y correspond if X, Y $\in$ S.

CORR-KD is violated if a pair of oral stops fails to correspond.

The third constraint needed to account for the Ngbaka pattern is a constraint that requires that corresponding output segments agree for the feature [voice]. The relevant constraint is IDENT-CC(VOI), which is defined in (3) (based on Walker 2000, 538).

(3) IDENT-CC(VOI) – Let X be a consonant in the output and Y be any correspondent of X in the output. If X is [α voice], then Y is [α voice].

IDENT-CC(VOI) is violated if corresponding segments within an output string do not agree for the feature [voice].

The final constraint needed to account for the Ngbaka pattern is a constraint that requires that corresponding input and output segments agree for the feature [voice]. The relevant constraint is IDENT-IO(VOI), which is defined in (4).

(4)   IDENT-IO(VOI) – Let X be a segment in the output and let Y be a correspondent of X in the input. If Y is [α voice], then X is [α voice].

IDENT-IO(VOI) is violated if a segment in the output does not have the same value for the feature [voice] as its input correspondent.

The ranking of these four constraints in (5) accounts for the Ngbaka pattern.

(5)   IDENT-CC(VOI), CORR-TD ≫ IDENT-IO(VOI) ≫ CORR-KD

Tableau (6) shows how this ranking accounts for the fact that homorganic stops must agree for voicing.

(6)

	/tida/	IDENT-CC(VOI)	CORR-TD	IDENT-IO(VOI)	CORR-KD
a. ☞	t$_i$it$_i$a			*	
b.	tida		*!		*
c.	t$_i$id$_i$a	*!			

Comparing candidates (a) and (b) in (6), we see that it is more important for homorganic stops in the output to correspond than it is for an output segment to agree with its input correspondent for voicing. Comparing candidates (a) and (c), we see that it is more important for corresponding output segments to agree for the feature [voice] than it is for corresponding output and input segments to agree for the same feature. If we consider all of the candidates at once, we see that both IDENT-CC(VOI) and CORR-TD must outrank IDENT-IO(VOI) in order to generate the Ngbaka pattern. If either the IDENT-SS or the CORR-SS constraint were ranked below the IDENT-IO constraint, a fully faithful candidate would be optimal. This is partially illustrated in tableau (7), which shows how the current analysis accounts for the fact that heterorganic stops are not compelled to agree for voicing.

(7)

	/gɔtɔ/	IDENT-CC(VOI)	CORR-TD	IDENT-IO(VOI)	CORR-KD
a. ☞	gɔtɔ				*
b.	g$_i$ɔd$_i$ɔ			*!	

In tableau (7), we see that, because CORR-KD is ranked below IDENT-IO(VOI), it is more important for output segments to be faithful to their input correspondents for the feature voicing than it is for heterorganic stops to correspond. Since IDENT-CC(VOI) is only violated when the output segments that fail to agree for voicing correspond, it is irrelevant to the optimal candidate in (7), in spite of its relatively high ranking.

2.2   ABC and Blocking

Initially, ABC was applied to consonant harmony, from which opacity is virtually absent (Hansson 2001, §3.2.2; Rose & Walker 2004, §2.3), and its ability to capture extreme transparency was seen as its greatest virtue. In fact, it was even assumed that blocking effects could not be generated with ABC (see the introduction to Hansson 2007). The assumption was that any segments that are not targets of harmony themselves and that come between the trigger and target of harmony, simply do not enter into the correspondence relation with either of those segments. Since the only way that a segment can participate in harmony under ABC is by entering into a correspondence relation,

non-targets were assumed always to be transparent. However, Hansson (2007) proved that it is, in fact, possible to model some blocking effects in ABC.

Using an invented example of consonant harmony, Hansson showed that it is possible to model cases of blocking where the potential target of harmony is at least as similar to the opaque segment as it is to the trigger of harmony[4]. Although Hansson shows that it is possible to generate this type of blocking effect with ABC, he still maintains that there are known cases of opacity that cannot be modeled in ABC. In particular, he says that under ABC "*a segment carrying the agreement-triggering feature value cannot be opaque*" (2007, 406, his emphasis). Following on this reasoning, he specifically cites the case of Khalkha Mongolian rounding harmony, in which high rounded vowels are opaque, as a harmony system that cannot be analyzed as ABC.

Contrary to this claim, Hansson (2006a) shows that it is possible to analyze Khalkha rounding harmony as ABC, but his analysis requires the addition of a new type of constraint. The new type of constraint is a UNIFORMITY-VV constraint, which is analogous to McCarthy & Prince's (1995) anti-coalescence constraint, UNIFORMITY-IO. The particular UNIFORMITY-VV constraint that is needed to account for the Khalkha data is given in (8) (based on Hansson 2006a, (63a)).

(8) UNIFORMITY-$V_L V_R$ – No vowel has multiple correspondent vowels preceding it: *$[V_i \dots V_j \dots V_{i,j}]$.
For $x,y,z \in$ Output and $x < z$ and $y < z$, if x corresponds to z and y corresponds to z, then $x = y$.

The primary aim of the following section is to demonstrate that, in fact, the Khalkha data can be modeled without any addition to the basic model of ABC.

3   Khalkha data and analysis

In the current section, I show that ABC in its basic form actually is capable of handling Khalkha Mongolian rounding harmony. Khalkha rounding harmony is a particularly interesting test case for ABC for several reasons. As Hansson (2006a) clearly showed, similarity plays a crucial role in the harmony; only non-high vowels act as triggers and targets of harmony. For this reason, it seems especially appropriate to apply ABC to Khalkha rounding harmony, given the importance of similarity between interacting segments in the model. Additionally, the harmony offers a challenge for the theory because high rounded segments block rounding harmony and Hansson (2007) has claimed that it is not possible to account for this type of segmental opacity without adding to the basic model of ABC.

In §3.1, I introduce the basic harmony data[5], leaving aside transparent and opaque segments for later subsections. I then offer an ABC analysis of the basic harmony data. In §3.2, I offer data that shows that [i] is transparent to rounding harmony and then show how the ABC analysis of the basic harmony data accounts for this transparency. In §3.3, I introduce data that shows that there is a vowel [e] that is opaque to rounding harmony. Then I expand the ABC analysis of rounding harmony to account for the opacity of [e]. Finally, in §3.4, I introduce data that shows that high rounded vowels are opaque to rounding harmony and then I expand the ABC analysis developed

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[4]While Hansson uses a hypothetical example of consonant harmony, in §3.3, I will show that an opaque segment of just this type is actually attested in Khalkha rounding harmony.

[5]All of the data in this section are taken from Svantesson *et al.* (2005).

up to that point so that it is able to account for the opacity of high rounded vowels. Crucially, this analysis will not involve any addition to the basic model of ABC.

3.1 Basic Harmony

The surface Khalkha vowel inventory is given in (9).

(9)

		unrounded		rounded	
high	+ATR	i		u	ui
	-ATR			ʊ	ʊi
non-high	+ATR	e		o	
	-ATR	a	ai	ɔ	ɔi

If the initial syllable of a word contains a non-high round vowel ([o] or [ɔ]), all following non-high vowels in the word are round, as well. Harmony conditions suffix alternations, as shown with the Direct Past suffix in (10)[6]. Compare the form of the Direct Past suffix when it attaches to 'give', 'enter', and 'dart out' (-ʈo, -ʈɔ) to the form when the suffix attaches to the other verbs (-ʈe, -ʈa).

(10) +ATR   -ATR
      uc-ʈe   'to see'   xʊnʲ-ʈa   'to pleat'
      tuir-ʈe   'to be stunned'   ʋiʈ-ʈa   'to cry'
      xeːʈ-ʈe   'to decorate'   jaw-ʈa   'to go'
                                              sairx-ʈa   'to brag'
      og-ʈo   'to give'   ɔr-ʈɔ   'to enter'
                                              cʰɔiʈ-ʈɔ   'to dart out'

Four constraints are needed to account for the basic harmony pattern. Two of these constraints are from the standard ABC inventory, one CORR-SS constraint and one IDENT-SS constraint. First, since non-high vowels interact in harmony, we need a constraint that compels non-high vowels to correspond. The relevant constraint is CORR-OE, which is defined in (11).

(11) CORR-OE[7] – Let S be an output string of segments and let X and Y be segments specified [-cons, +son, -hi]. X and Y correspond if X, Y ∈ S.

CORR-OE is violated if non-high vowels in an output string fail to correspond.

The constraint that requires corresponding segments to agree in roundness is IDENT-VV(RD), which is given in (12).

(12) IDENT-VV(RD) – Let X be a segment in the output and let Y be a correspondent of X in the output. If X is [α round], then Y is [α round].

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[6]In addition to rounding harmony, Khalkha has ATR harmony, which I will not discuss in this paper. See Svantesson *et al.* (2005) for a description of the harmony.

[7]For the purposes of this paper, I will be evaluating all CORR-VV and IDENT-VV constraints locally, rather than globally. Hansson (2007) demonstrates that local evaluation of IDENT-SS constraints is necessary to avoid pathological predictions. In the appendix, I demonstrate that it is also necessary to evaluate CORR-SS constraints locally in order to avoid the same pathological predictions.

IDENT-VV(RD) is violated if an output segment does not have the same value for the feature [round] as the nearest preceding and following corresponding output segments.

The third constraint needed to account for the basic harmony pattern is a constraint that requires that corresponding input and output segments agree for the feature [round]. The relevant constraint is IDENT-IO(RD), which is defined in (13).

(13)   IDENT-IO(RD) – Let X be a segment in the output and let Y be a correspondent of X in the input. If Y is [α round], then X is [α round].

IDENT-IO(RD) is violated if a segment in the output does not have the same value for the feature [round] as its input correspondent.

The final constraint needed to account for the basic harmony pattern is a constraint that requires that output segments in an initial syllable of the root agree with their input correspondent for the feature [round]. The relevant constraint is IDENT-IO-σ_1(RD), which is defined in (14). This is the constraint that accounts for the left-to-right directionality of harmony.

(14)   IDENT-IO-σ_1(RD) – Let X be a segment in the root-initial syllable and let Y be a correspondent of X in the input. If Y is [α round], then X is [α round]. (Beckman 1998)

IDENT-IO-σ_1(RD) is violated if an output segment in the first syllable of the root does not have the same value for the feature [round] as its input correspondent.

One ranking of these four constraints that accounts for the basic harmony pattern is given in (15)[8].

(15)   IDENT-IO-σ_1(RD), CORR-OE $\gg$ IDENT-VV(RD) $\gg$ IDENT-IO(RD)

Tableau (16) shows how the ranking in (15) generates the basic harmony pattern.

(16)

/og-ʤe/	IDENT-IO-σ_1(RD)	CORR-OE	IDENT-VV(RD)	IDENT-IO(RD)
a. ☞ o_igʤo$_i$				*
b. o_igʤe$_i$			*!	
c. ogʤe		*!		
d. e_igʤe$_i$	*!			*

Comparing candidate (a) and (b) in (16), we see that it is better to have an output segment disagree with its input correspondent for the feature [round] than it is to have corresponding output segments disagree for the same feature. This is the result of the ranking IDENT-VV(RD) $\gg$ IDENT-IO(RD). (a) and (c) show that it is better to have an output segment disagree with its input correspondent for the feature [round] than it is to have non-high vowels in a word fail to correspond. This is the result of the ranking CORR-OE $\gg$ IDENT-IO(RD). Finally, (d) loses out to (a) because it is preferable to have an output segment that does not agree with its input correspondent in a non-initial syllable. This is the result of the presence of IDENT-IO-σ_1(RD) within the constraint set.

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[8]The fully articulated ranking in (15) is consistent with the basic harmony pattern, but cannot be established based on the basic pattern alone. The only rankings necessary to account for the basic harmony pattern are CORR-OE $\gg$ IDENT-IO(RD) and IDENT-VV(RD) $\gg$ IDENT-IO(RD). Simply having the constraint set include IDENT-IO-σ_1(RD) is enough to guarantee that the direction of harmony is left-to-right. The specific ranking of IDENT-IO-σ_1(RD) does not matter. However, the ranking of the constraints given in (15) will be necessary to account for the opaque segments discussed in later subsections.

3.2 Transparent [i]

As shown in (17), the high unrounded vowel, [i], is transparent to rounding harmony[9]. Note that the form of the Reflexive suffix (-o, -ɔ) is the same regardless of whether the Accusative suffix (-i) precedes it or not.

(17) Reflexive   Accusative Reflexive
      poːr-o   poːr-ig-o   'kidney'
      xɔːʑ-ɔ   xɔːʑ-ig-ɔ   'food'

Under ABC, the constraints and constraint ranking that account for the basic harmony pattern can also account for transparent [i], without addition or modification. Tableau (18) shows how the ranking in (15) accounts for the transparency of [i].

(18)

/poːr-ig-e/		IDENT-IO-σ_i(RD)	CORR-OE	IDENT-VV(RD)	IDENT-IO(RD)
a. ☞	poː$_i$rigo$_i$				*
b.	poː$_i$rige$_i$			*!	
c.	poːrigo		*!		
d.	poːri$_i$ge$_i$		*!		
e.	peː$_i$rige$_i$	*!			*
f.	poː$_i$ru$_i$go$_i$				**!

Comparing candidates (a) and (b) in (18), we see that it is better to have an output segment disagree with its input correspondent for the feature [round] than it is to have corresponding output segments disagree for the feature [round]. The fact that [i] is present between the corresponding output segments in candidate (b) is irrelevant because IDENT-VV(RD) only compares corresponding output segments. Turning to candidates (c) and (d), we see that it is consistently better to have an output segment disagree with its input correspondent for the feature [round], as in (a), than it is to have non-high vowels in a word fail to correspond, as in (c) and (d). This is true regardless of whether [i] is present between the non-high vowels, as in (18), or not, as in (16). This is because [i] is a high vowel and, so, is irrelevant for the evaluation of CORR-OE. Comparing candidates (a) and (e), we see that the presence of [i] does not change the fact that if an output segment must disagree with its input correspondent for the feature [round], that output segment must not be in the initial syllable. Finally, (f) demonstrates that [i] fails to undergo harmony because, if it did, there would be an extra violation IDENT-IO(RD). There is no constraint that outranks IDENT-IO(RD) and compels [i] to correspond with the surrounding non-high vowels. CORR-OE does not require that [i] correspond because [i] is a high vowel. Also, there is no constraint that compels high vowels and non-high vowels to correspond that outranks IDENT-IO(RD) in this analysis. From the perspective of the current analysis, [i] is simply not similar enough to the triggers and targets of harmony to participate in rounding harmony. It is not the appropriate height to be subject to CORR-OE or any other CORR-SS constraints that would compel it to participate in harmony are not ranked highly enough to have any effect.

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[9]Svantesson *et al.* (2005) report that [i] is sometimes opaque to rounding harmony (see pg. 51). In spite of this, I will follow them is treating [i] as transparent for the purposes of my analysis.

3.3 Opaque [e]

In Khalkha there are two [e] vowels. One of them alternates with [o], [a], and [ɔ], as shown in (10) above. The other alternates with the diphthongs [ai] and [ɔi], as shown in (19). Compare the form of the Comitative suffix following 'gown' and 'kidney' (-tʰe) to its form following 'paper' (-tʰai) and 'food' (-tʰɔi). Based on this behavior, I assume, following Svantesson *et al.* (2005), that this second [e] is a diphthong underlyingly.

(19) | Reflexive | Comitative Reflexive | |
|---|---|---|
| teːʐ-e | teːʐ-tʰe-ge | 'gown' |
| poːr-o | poːr-tʰe-ge | 'kidney' |
| cʰaːs-a | cʰaːs-tʰai-ɢa | 'paper' |
| xɔːʐ-ɔ | xɔːʐ-tʰɔi-ɢɔ | 'food' |

In addition to alternating with diphthongs, this [e] is notable because it blocks rounding harmony, in addition to failing to undergo it, as shown in (19)[10]. Compare the vowel in the Reflexive suffix in 'kidney' (-ge) when it appears following the Comitative suffix (-tʰe) to the vowel when it appears alone (-o).

In order to account for opaque [e], we need a constraint that guarantees that the vowel that alternates with [ai] and [ɔi] always surfaces as [e] following a [+ATR] vowel. The relevant constraint is *EI/OI[11], which is given in (20).

(20) *EI/OI – /ei/ surfaces as [e] in [+ATR] words[12].

This constraint is violated if the input /ei/ corresponds to anything other than [e] in the output of a [+ATR] word. Since this constraint is never violated, it is undominated. Adding *EI/OI to the current constraint ranking gives us the ranking in (21).

(21) *EI/OI, IDENT-IO-σ_1(RD), CORR-OE ≫ IDENT-VV(RD) ≫ IDENT-IO(RD)

Tableau (22) shows how ranking (21) accounts for opaque [e].

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[10]Svantesson *et al.* (2005) report that the [e] that alternates with diphthongs is transparent to rounding harmony according to the spelling norm, as represented by the orthographic dictionary by Damdinsürèn and Osor (1983) (see Svantesson *et al.* 2005, 51). However, based on the fact that it is opaque in the colloquial speech of Ulaanbaatar, they treat this [e] as opaque, as do I for the purposes of the current analysis.

[11]*EI/OI is actually a place holder. In order to properly account or the behavior of the underlying diphthong /ei/ in [+ATR] words, multiple markedness and faithfulness constraints will be necessary. For the purposes of the current paper, I will not work out a full account of the behavior of the underlying diphthong. The details of this account are not crucial to demonstrating that ABC can account for the opacity of [e]. Assuming that it is possible to come up with an OT account for the fact that the underlying /ei/ surfaces as [e] following [o], the current analysis shows that it is possible to account for the fact that this [e] blocks rounding harmony under ABC.

[12]As mentioned in footnote 6, Khalkha also has ATR harmony. As a result, all of the vowels in a given word are either [+ATR] or [-ATR] (with the exception of [i], which is also transparent to ATR harmony). When I refer to a [+ATR] word, I mean a word in which all of the vowels are [+ATR].

(22)

/poːr-tʰei-go/	*ei/oi	Ident-IO-σ_1(rd)	Corr-OE	Ident-VV(rd)	Ident-IO(rd)
a. ☞ poːᵢrtʰeᵢgeᵢ				*	*
b. poːᵢrtʰeᵢgoᵢ				**!	
c. poːᵢrtʰegoᵢ			*!*		
d. poːrtʰego			*!*		
e. peːᵢrtʰeᵢgeᵢ		*!			**
f. poːᵢrtʰoᵢgoᵢ	*!				*

Comparing candidates (a) and (b), we see that the local evaluation of Ident-VV(rd) is crucial to accounting for opaque [e]. In the optimal candidate, there is only a single pair of corresponding vowels that fail to agree for the feature [round] and do not have another corresponding vowel in between them, namely the vowels in the first and second syllables. In candidate (b), on the other hand, there are two pairs of corresponding vowels that fail to agree for the feature [round] and do not have another corresponding vowel in between them. In addition to the vowels in the first and second syllable, the vowels in the second and third syllables correspond but fail to agree in roundness. Comparing candidate (a) to candidates (c) and (d), we see that the remaining candidates in which [e] is transparent to rounding harmony are ruled out because it is more important for non-high vowels to correspond than for all corresponding vowels to agree for the feature [round]. This is the result of the ranking Corr-OE ≫ Ident-VV(rd). A comparison of (a) and (e) shows that it is better to have a pair of non-high vowels fail to correspond than it is to have an output vowel in the first syllable disagree with its input correspondent for the feature [round]. This is the result of the ranking Ident-IO-σ_1(rd) ≫ Corr-OE. Finally, we see that it is more important to have the appropriate output correspondent for the underlying diphthong /ei/ than it is to have all of the non-high vowels in the word correspond, as in (f). This is the result of the ranking *ei/oi ≫ Corr-OE.

It is interesting to note that the [e] that alternates with diphthongs is an attested example of the type of opaque segment that Hansson (2007) showed it is possible to account for with ABC. Although [e] cannot undergo harmony because of the combination of markedness and faithfulness constraints that *ei/oi is standing in for, it does block harmony because it is just as similar to the potential targets of harmony as is the trigger of harmony. As a non-high vowel, opaque [e], just like the triggers and potential targets of harmony, is subject to Corr-OE.

3.4 Opaque [u] and [ʊ]

High rounded vowels ([u] and [ʊ]) block rounding harmony, as shown in (23). Compare the form of the Direct Past suffix (-ʤe, -ʤa) when it follows the Causative suffix (-uʤ, -ʊʤ) to its form when it appears alone (-ʤo, -ʤɔ).

(23)

Direct Past	Causative Direct Past	
og-ʤo	og-uʤ-ʤe	'to give'
ɔr-ʤɔ	ɔr-ʊʤ-ʤa	'to enter'

Hansson (2007) claimed that opaque high rounded vowels in Khalkha rounding harmony could not be modeled with the basic model of ABC because they carry the harmonizing feature. In the current section, I show that it actually is possible to account for these segments without adding to the basic model of ABC.

The current constraint ranking incorrectly predicts that high rounded vowels should be transparent to rounding harmony, as shown in (24)[13].

(24)

	/og-uʐ-ʐe/	IDENT-IO-σ_1(RD)	CORR-OE	IDENT-VV(RD)	IDENT-IO(RD)
a. (☞)	$o_i gu_i ʐʐe_i$			*!	
b. (☞)	$o_i gu_i ʐʐe$		*!		
c. ☺	$o_i guʐʐo_i$				*

In (24), we see that the current constraint ranking rules out both of the candidates that are consistent with an output in which [u] blocks rounding harmony. Comparing candidates (a) and (c), we see that [u] corresponding to the non-high vowels does not change the fact that it is better for an output segment to disagree with its input correspondent for the feature [round] than it is for corresponding output segments to disagree for the same feature. Comparing candidates (b) and (c), we see that having [u] correspond with the initial vowel does not change the fact that it is more important for non-high vowels in the output to correspond than it is for an output segment to agree with its input correspondent for the feature [round]. Clearly, the current analysis is insufficient to account for the fact that high rounded vowels are opaque to rounding harmony.

Two additional constraints are needed to account for the opacity of high rounded vowels. First, a constraint that compels rounded vowels to correspond is needed. The relevant constraint is CORR-OU, which is defined in (25).

(25) CORR-OU – Let S be an output string of segments and let X and Y be segments specified [-cons, +son, +round]. X and Y correspond if X, Y ∈ S.

CORR-OU is violated if a rounded vowel fails to correspond with the nearest preceding or following rounded vowel.

The other constraint needed to account for the opacity of high rounded vowels is a constraint that requires that corresponding output segments agree for the feature [high]. The relevant constraint is IDENT-VV(HI), which is defined in (26).

(26) IDENT-VV(HI) – Let X be a segment in the output and let Y be a correspondent of X in the output. If X is [α high], then Y is [α high].

IDENT-VV(HI) is violated if an output segment does not have the same value for the feature [high] as the nearest preceding and following corresponding output segments. It is important to note that both CORR-OU and IDENT-VV(HI) are from the standard inventory of ABC constraints. No new constraint type is needed to account for the opacity of high rounded vowels.

Adding these two constraints to the current analysis to yield the ranking in (27) allows us to account for the opacity of high rounded vowels.

(27) IDENT-IO-σ_1(RD), CORR-OE, CORR-OU ≫ IDENT-VV(HI) ≫ IDENT-VV(RD) ≫ IDENT-IO(RD)

Tableau (28) shows how this ranking accounts for the fact that high rounded vowels block rounding harmony[14].

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[13]*EI/OI is not relevant to the account of opaque high rounded vowels, so I will be excluding it from the rankings and tableaux in this subsection.

[14]There are two relevant suboptimal candidates that I do not consider in this tableau and each of them requires a new constraint. The first candidate is one in which the high vowel in the input corresponds to a non-high vowel in

(28)

/og-uʐ-ʐo/	IDENT-IO-σ_1(RD)	CORR-OE	CORR-OU	IDENT-VV(HI)	IDENT-VV(RD)	IDENT-IO(RD)
a. ☞ $o_{i,j}$gu$_i$ʐʐe$_j$				*	*	*
b. $o_i$gu$_i$ʐʐo$_i$				**!		
c. $o_i$guʐʐo$_i$			*!*			
d. $o_i$gu$_i$ʐʐo		*!	*	*		
e. $e_i$guʐʐe$_i$	*!					**

Comparing candidates (a) and (b) in tableau (28), we see that it is crucial to minimize the number of pairs of corresponding output segments that do not agree for the feature [high]. It is more important than having all of the pairs of corresponding output segments agree for the feature [round]. This is the result of the ranking IDENT-VV(HI) ≫ IDENT-VV(RD). Also, it is more important than having output segments and their input correspondents agree for the feature [round]. This is the result of the ranking IDENT-VV(HI) ≫ IDENT-IO(RD). Comparing candidates (a) and (c), we see that it is more important to have all of the rounded vowels in the output correspond than it is to have corresponding vowels agree for the feature [high]. This is the result of the ranking CORR-OU ≫ IDENT-VV(HI). Comparing candidates (a) and (d), we see that it is more important for all the non-high vowels in the output to correspond than it is for corresponding vowels to agree for the feature [high]. This is the result of the ranking CORR-OE ≫ IDENT-VV(HI). Finally, we see that it is more important for a vowel in the first syllable of the output to agree with its input correspondent for the feature [round] than it is for corresponding vowels to agree for the feature [high]. This is the result of the ranking IDENT-IO-σ_1(RD) ≫ IDENT-VV(HI).

From the perspective of the current analysis, high rounded vowels are opaque because they are similar enough to the triggers of rounding harmony to participate in harmony, but they are not sufficiently similar to the targets of harmony to be full participants[15]. That is to say that because high rounded vowels are rounded, they are compelled to correspond with the triggers of harmony,

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the output. In order to rule this candidate out, we need a constraint that requires input and output correspondents to have the same specification for height. IDENT-IO(HI) is just such a constraint. As we see in tableau (1), having IDENT-IO(HI) outrank IDENT-VV(HI) accounts for the fact that candidate (b), in which a high vowel in the input corresponds to a non-high vowel in the output, is suboptimal.

(1)

/og-uʐ-ʐo/	IDENT-IO-σ_1(RD)	CORR-OE	CORR-OU	IDENT-IO(HI)	IDENT-VV(HI)	IDENT-VV(RD)	IDENT-IO(RD)
a. ☞ $o_{i,j}$gu$_i$ʐʐe$_j$					*	*	*
b. $o_i$go$_i$ʐʐo$_i$				*!			

The second relevant candidate is one in which the high rounded vowel in the input corresponds to a high unrounded vowel in the output. In order to rule this candidate out, we need a constraint that targets high vowels specifically and requires that output segments and their input correspondents have the same specification for the feature [round]. IDENT-I$_{hi}$O(RD) is just such a constraint. As we see in tableau (2), having this constraint outrank IDENT-VV(HI) accounts for the fact that candidate (b), in which a high rounded vowel in the input corresponds to a high unrounded vowel in the output, is suboptimal.

(2)

/og-uʐ-ʐo/	IDENT-IO-σ_1(RD)	CORR-OE	CORR-OU	IDENT-I$_{hi}$O(RD)	IDENT-VV(HI)	IDENT-VV(RD)	IDENT-IO(RD)
a. ☞ $o_{i,j}$gu$_i$ʐʐe$_j$					*	*	*
b. $o_i$giʐʐo$_i$				*!			

It is not clear if IDENT-I$_{hi}$O(RD) is as well motivated as IDENT-IO(HI), but it appears to be just as necessary for the current analysis.

[15] I was inspired to look at the opacity of high rounded vowels in this way by the analysis of Khalkha rounding harmony in Goldsmith (1985).

which are also rounded. However, because high rounded vowels are high, they are not similar enough to the targets of rounding harmony, non-high vowels in non-initial syllables, which are free to be unrounded because they are not subject to IDENT-IO-σ_1(RD), to be required to correspond with those targets. The idea that high rounded vowels are sufficiently similar to the triggers of harmony is captured by the fact that the constraint compelling all rounded vowels to correspond, CORR-OU, outranks the constraint that is violated by high and non-high vowels corresponding with each other, IDENT-VV(HI). The idea that high rounded vowels are not sufficiently similar to the targets of harmony is captured by the fact that no constraint compelling high rounded vowels to correspond with non-high vowels in general outranks IDENT-VV(HI).

Taking a step back from the details, we see that the current analysis highlights the fact that the same tendency for already similar segments to interact, captured in ABC by CORR-VV constraints, that leads to long distance agreement can also end up preventing possible agreement. That is to say, similarity can play a role not only in driving but also in blocking harmony. Importantly, this insight is relevant beyond Khalkha rounding harmony. As Walker (2009) shows, an ABC analysis analogous to the one presented here can account for ATR harmony in Menominee, in which +ATR [ə] is opaque. It remains to be seen just how many other languages can be insightfully analyzed in the same way, but extending the approach has already borne fruit in highlighting an interesting commonality between Khalkha rounding harmony and Menominee ATR harmony that might otherwise have been missed.

4   Finnish Data and Analysis

The fact that it is possible to analyze the seemingly problematic case of Khalkha rounding harmony as ABC (Rose & Walker 2004) raises the question of whether all cases of vowel harmony can be accounted for with the model. Analyzing vowel harmony as ABC is appealing given the model's ability to handle extensive segmental transparency. This ability is relevant because segmental transparency is relatively common in vowel harmony systems and handling such transparency is a non-trivial problem in OT. Segmental transparency is a problem for OT approaches to vowel harmony because it can be viewed as a type of derivational opacity (Lightner 1965, Krämer 2003) and derivational opacity poses a considerable challenge in OT (McCarthy 2007). Previous approaches to segmental transparency in OT have included targeted constraints (Baković & Wilson 2000) and three way local constraint conjunction (Krämer 2003). Neither of these approaches is ideal. Targeted constraints essentially sneak derivation into OT in that they require comparison between the output form and a non-input form, while three way local constraint conjunction has no independent motivation (see Baković 2004 for additional criticisms of Krämer's approach). ABC has no such problems. It is completely non-derivational and it was initially proposed for the analysis of consonant harmony systems.

In order to demonstrate how ABC can handle transparent vowels, I will offer an analysis of Finnish palatal harmony, which includes perhaps the best-known example of vowel transparency. After a brief outline of the basic vowel harmony facts and a presentation of an analysis in §4.1, I will illustrate the apparent problem that transparent vowels pose in §4.2. Then in §4.3 I will offer a representational solution to this problem, which will require no change or addition to either OT or ABC. Finally, in §4.4, I will discuss the implications of the representational solution, showing that the representational solution I propose can account for completely unrelated data that would otherwise be difficult to handle in OT.

4.1 Basic harmony

The vowel inventory of Finnish is given in (29)[16].

(29) Finnish vowel inventory (IPA symbol given in brackets where orthography and IPA differ)

	front		back	
	unrounded	rounded	unrounded	rounded
high	i	y		u
mid	e	ö [ø]		o
low	ä [æ]		a	

In Finnish, all of the harmonic (or non-transparent) vowels in a word agree in backness, as shown in (30)

(30) a. pöytä   'table'   b. pöytä-nä   'table' (essive)
          hämärä   'dusk'   hämärä-nä   'dusk' (essive)
          pouta   'fine weather'   pouta-na   'fine weather' (essive)

In (30a), we see that harmony applies within roots. In (30b), we see that it conditions suffix alternations. Notice that the essive suffix contains a front vowel ($\ddot{a}$) when it follows a root containing only front vowels and a back vowel (a) when it follows a root containing only back vowels. Accounting for this basic harmony pattern with ABC is completely straightforward; only four constraints are needed. First, since harmony is not parasitic on any feature, there must be a constraint compelling all vowels to correspond. The relevant constraint, CORR-VV, is given in (31).

(31) CORR-VV – Let S be an output string of segments and let X and Y be segments that agree for the features [-cons, +son]. X and Y correspond if X, Y ∈ S.

CORR-VV is violated if a vowel does not correspond to the nearest preceding and following vowel.

It is not enough to simply require that vowels correspond, in order to generate harmony we need IDENT-VV(BK), which requires that corresponding vowels agree for the feature [back]. This constraint is defined in (32).

(32) IDENT-VV(BK) – Let X be a segment in the output and let Y be a correspondent of X in the output. If X is [α back], then Y is [α back].

IDENT-VV(BK) is violated if an output segment does not have the same value for the feature [back] as the nearest preceding and following corresponding output segments.

The third relevant constraint is IDENT-IO(BK), which is defined in (33) and requires that output segments agree with their input correspondents for the feature [back].

(33) IDENT-IO(BK) – Let X be a segment in the output and let Y be a correspondent of X in the input. If Y is [α back], then X is [α back].

IDENT-IO(BK) is violated if a segment in the output does not have the same value for the feature [back] as its input correspondent.

Finally, in order to account for the fact that vowels in suffixes agree with vowels in the root, we need a constraint that favors root faithfulness to affix faithfulness. IDENT-IO-ROOT(BK), defined in (34) is just such a constraint.

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[16]All data are taken from Ringen & Heinämäki (1999), unless otherwise noted.

(34)   IDENT-IO-ROOT(BK) – Let X be a segment in the root and let Y be a correspondent of X
in the output. If X is [α back], then Y is [α back]. (Beckman 1998)

IDENT-IO(BK) is violated if a segment in the root in the output does not have the same value for
the feature [back] as its input correspondent.

In order to account for harmony, it is crucial for both CORR-VV and IDENT-VV(BK) to outrank
IDENT-IO(BK) and IDENT-IO-ROOT(BK). These rankings account for the fact that it is more
important for output vowels to agree with each other for [back] than it is for them to agree with
their input correspondents for the same feature. Beyond these, no other rankings can be established.
CORR-VV and IDENT-VV(BK) do not compete, since they work together to generate harmony.
The IDENT-IO constraints also do not conflict because IDENT-IO-ROOT(BK) is just a special case
of IDENT-IO(BK). So any time IDENT-IO-ROOT(BK) is violated, so is IDENT-IO(BK). No ranking
of IDENT-IO-ROOT(BK) is needed to account for the fact that root faithfulness is more important
than affix faithfulness; the existence of the constraint is enough. With all of this in mind, the total
ranking necessary to account for harmony is given in (35).

(35)   CORR-VV, IDENT-VV(BK) ≫ IDENT-IO-ROOT(BK), IDENT-IO(BK)

The tableau in (36) shows how this ranking generates palatal harmony.

(36)

	/pouta-nä/	CORR-VV	IDENT-VV(BK)	IDENT-IO-ROOT(BK)	IDENT-IO(BK)
a. ☞	po$_i$u$_i$ta$_i$-na$_i$				*
b.	po$_i$u$_i$ta$_i$-nä	*!			
c.	po$_i$u$_i$ta$_i$-nä$_i$		*!		
d.	pö$_i$y$_i$tä$_i$-nä$_i$			*!**	***

4.2   The apparent problem of transparent vowels

The non-low front unrounded vowels (*i* and *e*) are not harmonic. They can appear in words
containing front vowels (37a) or back vowels (37b).

(37)   a.   käsi   'hand'   b.   koti   'home'
kesy   'tame'   vero   'tax'

Additionally, the non-low front unrounded vowels are transparent to palatal harmony. As shown
in (38)[17], harmonic vowels agree in backness even if there is non-low front unrounded vowel in
between them. Notice in that the backness of the suffix vowel is determined by the harmonic vowel
in the root, not the backness of the non-low front unrounded vowel. If the harmonic vowel is front,
the suffix vowel is front (38a). If the harmonic vowel is back, the suffix vowel is back (38b). This
is true regardless of whether the harmonic vowel is closer to or farther away from the suffix vowel
than the non-low front unrounded vowel.

(38)   front   back
a.   säde-ttä   'ray' (partitive)   b.   sade-tta   'rain' (partitive)
täti-llä   'aunt' (adessive)   Kati-lla   (woman's name)
kesy-llä   'tame' (adessive)   vero-lla   'tax' (adessive)

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[17] *täti-llä* and *Kati-lla* taken from Kim (2005).

The constraint ranking in (35) is insufficient to account for the transparency of non-low front unrounded vowels. Under this ranking, these vowels are predicted to undergo harmony, as shown in the tableaux in (39) and (40).

(39)

	/sade-ttä/	Corr-VV	Ident-VV(BK)	Ident-IO-root(BK)	Ident-IO(BK)
a. (☞)	sa$_i$de-tta$_i$	*!*			*
b. (☞)	sa$_i$de$_i$-tta$_i$		*!*		*
c. ☺	sa$_i$dɤ$_i$-tta$_i$			*	**

(40)

	/vero-lla/	Corr-VV	Ident-VV(BK)	Ident-IO-root(BK)	Ident-IO(BK)
a. (☞)	vero$_i$-lla$_i$	*!*			
b. (☞)	ve$_i$ro$_i$-lla$_i$		*!*		
c. ☺	vɤ$_i$ro$_i$-lla$_i$			*	*

In both tableaux we see that *e* is predicted not to be transparent. The high ranking of Corr-VV requires *e* to correspond with the nearest vowels, so candidate (a), which is consistent with transparency, is ruled out. If *e* does correspond, Ident-VV(BK) being so highly ranked forces it to agree with the nearest corresponding vowel for backness, which eliminates candidate (b), the other candidate that is consistent with transparency. This leaves candidate (c), in which *e* simply undergoes harmony.

The optimal forms in the tableaux in (39) and (40) are problematic not only because *e* is incorrectly predicted to undergo harmony, but because the forms include [ɤ]. This is an issue because non-low back unrounded vowels do not occur in Finnish at all. In order to account for this gap in the Finnish vowel inventory, we need an undominated constraint that rules out non-low back unrounded vowels, defined in (41).

(41)   *[-LO, +BK, -RD] – Output strings must not contain non-low back unrounded vowels.

It has often been noted that the vowels that transparent vowels in languages like Finnish would be expected to alternate with are just those vowels that are missing from the language's inventory (Kiparsky & Pajusalu 2003). Based on this, we might hope that adding *[-LO, +BK, -RD] to the analysis, which accounts for the gap in the vowel inventory, would also make it possible to account for the transparency of *i* and *e*. This is, however, not the case, as shown (42).

(42)

	/sade-ttä/	*[-LO, +BK, -RD]	Corr-VV	Ident-VV(BK)	Ident-IO-root(BK)	Ident-IO(BK)
a. (☞)	sa$_i$de-tta$_i$		*!*			*
b. (☞)	sa$_i$de$_i$-tta$_i$			*!*		*
c.	sa$_i$dɤ$_i$-tta$_i$	*!			*	**
d. ☺	sa$_i$de$_i$-ttä$_i$				*	*

The tableau in (42) shows that although adding *[-LO, +BK, -RD] to the analysis correctly rules out candidates like (c), which contain non-low back unrounded vowels, it incorrectly predicts that *i* and *e* should be opaque. Candidates (a) and (b) continue to be ruled out by the high ranking Corr-VV and Ident-VV(BK) constraints, which leaves candidate (d), in which the suffix vowel agrees with the closer vowel, *e*, rather than the harmonic vowel, *a*.

The problem is that under ABC segments are transparent because they are not similar enough to harmonic segments to be compelled to correspond. This accounts straightforwardly for segments

that are not sufficiently phonetically similar to harmony triggers and targets, like vowels in consonant harmony or high vowels in vowel harmonies that target only non-high vowels. But, unlike these transparent segments, Finnish *i* and *e* are just as similar to the harmonic segments as the harmonic segments are to each other. For example, *i* is at least as similar to *o* as *ä* is. As a result, there is no way to define a natural class including all of the harmonic segments, but excluding *i* and *e*. This means that since the CORR-VV constraint that drives palatal harmony is defined exclusively in terms of phonetic similarity and applies to all of the harmonic segments, it necessarily also applies to *i* and *e*. As a result, these vowels are predicted to be opaque rather than transparent. The solution to this problem is to define the CORR-VV constraint not in terms of phonetic similarity, but instead in terms of a more abstract type of similarity. In the next section propose a type of featural representation that makes such a solution possible.

4.3 A representational solution

In order to account for segmental transparency like that found in Finnish, I propose adding FEATURE STRENGTH to segments' featural representations. In addition to a value (e.g., + or - for binary features) each feature can have a strength level (either weak or strong) specified. While the value of a feature corresponds to phonetic properties of the segment (e.g., vowels with a relatively high second formant are [-back]), the strength level depends on the segment's phonological properties and so will depend on the system that the segment appears in. For example, in Finnish the strength of the feature [back] is a matter of contrast. 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 (e.g., *i* is weakly specified for the feature because there is no high *back* unrounded vowel). In (43), we revisit the Finnish vowel inventory with the addition of the strength of the feature [back].

(43) Finnish vowel inventory including feature strength for [back]

	front		back	
	weak	strong	weak	strong
high	i	y		u
mid	e	ö		o
low		ä		a

With the addition of feature strength, it is now possible to define a CORR-VV constraint that targets all and only the harmonic segments. The relevant constraint is given in (44).

(44) CORR-V$_S$V$_S$ – Let S be an output string of segments and let X and Y be segments that agree for the features [-cons, +son] and are strongly specified for the feature [back]. X and Y correspond if X, Y $\in$ S.

CORR-V$_S$V$_S$ is violated if a vowel strongly specified for the feature [back] does not correspond to the nearest preceding and following vowels that are also strongly specified for [back].

Since all of the harmonic vowels contrast with another segment based only on backness, they are strongly specified for [back], as shown in (45). Crucially, the transparent segments, which do not contrast with any other segment based only on [back], are weakly specified for the feature (also shown in 45). As a result, CORR-V$_S$V$_S$ only applies to harmonic vowels because it only compels vowels that are strongly specified for the feature [back] to correspond.

(45)   Specifications for the feature [back] for all Finnish vowels. A single $*$ for strength indicates weak specification, two indicates strong specification.

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

Adding CORR-$V_S V_S$ to the ranking, we find that it, not CORR-VV, is the CORR-SS constraint that must outrank to IDENT-IO-ROOT(BK) and IDENT-IO(BK) in order to generate harmony, while still accounting for the transparency of *i* and *e*. CORR-$V_S V_S$ must outrank the IDENT-IO constraints to account for the fact that harmonic vowels agree with each other regardless of their back value in the input. At the same time, CORR-VV must be outranked by at least one of the IDENT-IO constraints to account for the fact that transparent vowels are not required to agree with other vowels in backness[18]. The updated constraint ranking is given in (46)[19].

(46)   CORR-$V_S V_S$, IDENT-VV(BK) $\gg$ IDENT-IO-ROOT(BK) $\gg$ CORR-VV $\gg$ IDENT-IO(BK)

The tableaux in (47) and (48) show how this ranking generates transparency. Tableau (47) shows how the ranking accounts for the transparency of a medial vowel, while tableau (48) does the same thing for the transparency of an initial vowel.

(47)

/sade-ttä/	CORR-$V_S V_S$	IDENT-VV(BK)	IDENT-IO-ROOT(BK)	CORR-VV	IDENT-IO(BK)
a. ☞ sa$_i$de-tta$_i$				**	*
b. sä$_i$de$_i$-ttä$_i$			*!		*
c. sa$_i$de$_i$-ttä$_i$		*!			
d. sade$_i$-ttä$_i$	*!			*	

(48)

/vero-llä/	CORR-$V_S V_S$	IDENT-VV(BK)	IDENT-IO-ROOT(BK)	CORR-VV	IDENT-IO(BK)
a. ☞ vero$_i$-lla$_i$				*	*
b. ve$_i$rö$_i$-llä$_i$			*!		**
c. ve$_i$ro$_i$-llä$_i$		*!*			*
d. ve$_i$ro-llä$_i$	*!			**	

Comparing candidates (a) and (b) in both tableaux, we see that the candidate in which all of the vowels agree with *e*, (b), is ruled out because it is more important for vowels in the root to be faithful to their input correspondents for the feature [back] than it is for all vowels in the output to correspond. Moving on to candidates (c) and (d) we see that the high rankings of CORR-$V_S V_S$ and IDENT-VV(BK) prevent the current analysis from predicting that suffix vowels should agree with *i* or *e* rather than harmonic vowels. Candidate (c) is ruled out because all corresponding vowels must agree for [back], while candidate (d) is suboptimal because all vowels strongly specified for [back] must correspond. Focusing on these candidates in tableau (47) in particular, we see that these constraints being undominated is the reason that the current analysis predicts that *i* and *e* will not be opaque, but rather transparent.

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[18]I will justify the specific ranking of CORR-VV with respect to IDENT-IO(BK) and IDENT-IO-ROOT(BK) shortly.

[19]I am excluding *[-LO, +BK, -RD] here for reasons of space and clarity in tableau presentation, not because it is no longer necessary. Since the constraint is never violated, I assume that it is undominated and will not consider any candidates that violate it for the remainder of the paper.

Although suffix vowels agree in backness with the harmonic vowels in the root whenever there are harmonic vowels present, if a root contains only transparent vowels, the suffix vowels will agree with the transparent vowels, as shown in (49).

(49)　velje-llä　'brother' (adessive)
　　　　tie-llä　　'road' (adessive)

As shown in the tableau in (50), the ranking in (46) accounts not only for the transparency of front unrounded vowels, but for the fact that suffix vowels are front as well following roots containing only *i* and *e*.

(50)

		/tie-lla/	Corr-$V_S V_S$	Ident-VV(bk)	Ident-IO-root(bk)	Corr-VV	Ident-IO(bk)
a.	☞	ti$_i$e$_i$-llä$_i$					*
b.		tie-lla				*!**	
c.		ti$_i$e$_i$-lla				*!	
d.		ti$_i$e$_i$-lla$_i$		*!			

In tableau (50) we see that it is the very low ranking of Ident-IO(bk), the Ident-IO constraint relevant to suffix vowels, that accounts for the fact that suffix vowels agree with transparent vowels in the root in the absence of harmonic vowels. Since Ident-IO(bk) is outranked by Corr-VV, suffix vowels must correspond with the transparent vowels in the root, even if it means disagreeing with their input correspondents as a result (see candidates (b) and (c)). Also, as shown in candidate (d), because Ident-IO(bk) is outranked by Ident-VV(bk), if suffix vowels correspond to the root vowels, they must agree in backness, even the suffix vowels are unfaithful to their input correspondents as a result.

4.4　Implications of feature strength

The addition of feature strength has two main effects on segmental representations. First, it means that features are not just privative or binary, but can have as many as four possible specifications: - strongly specified, - weakly specified, + strongly specified, - strongly specified. Second, it has the effect of partially divorcing segments' featural representations from their phonetic substance; differences in feature strength have no phonetic consequence. Both of these effects have some precedent. De Lacy (2002) and Mortensen (2006) move away from using just binary and privative features by introducing feature scales, which can have more than two possible values or positions. De Lacy argues that the change is needed to account for the fact that it is sometimes the most marked element, rather than the least marked element, that is preserved by a phonological process (e.g., preservation of dorsals rather than coronals in assimilation in Pali). Mortensen argues that the change is necessary to account for chain shifts and circle shifts (e.g., in tone sandhi). Since Mortensen's scales are not always phonetically grounded, they also offer an example of the move away from having (auto)segmental representations simply reflect phonetic substance. In her account of the fact that the reflexes of superclosed segments in Bantu trigger consonant mutation, while other, phonetically identical, segments do not, Zoll (1995) also shows that it is not enough for segments' representations to simply reflect their phonetic substance.

While it is good that the primary representational effects of adding feature strength have previously been argued to be necessary, it is more important that doing so has utility beyond allowing us to account for transparent vowels like those found in Finnish. In particular, adding feature strength

makes it possible to account for phonetically identical segments that exhibit different phonological behavior. For example, in Kashaya there are two /i/s, which are pronounced the same, but behave differently with respect to several phonological processes (Buckley 1994). One [i] mutates following [m] and [d], surfacing as [a] and [u], respectively, as shown in (51). The other [i], which I will indicate as /î/ underlyingly following Buckley, simply surfaces as [i] following these consonants, as shown in (52).

(51) a. /mi/ → [ma]   Based on Buckley's (5)
          pʰa-nem-i   →   pʰanemá   'punch him!'
          mo-m-in   →   momán   'while running across'

      b. /di/ → [du]   Based on Buckley's (6)
          wa-ad-i   →   wa·du   'come here!'
          mo-m-ad-i   →   momá·du   'keep running accross'

(52) a. /mî/ → [mi]   Based on Buckley's (10)
          caqʰam-îbic-ʔ   →   caqʰamí·biʔ   'start to cut with a knife'
          qʰos̓am-îbic-ʔ   →   qʰos̓amí·biʔ   'winter to begin'

      b. /dî/ → [di]   Based on Buckley's (11)
          cahno-ad-îc̓-ʔ   →   cahno·dí́ʔ   'talk to oneself'
          cahno-ad-îyic̓-ʔ →   cahnodi·yíʔ   'talk to oneself'

The two [i]s also show different behavior following [q]. /i/, which mutates following [m] and [d], is also affected by a preceding /q/, surfacing as [a], as shown in (53). /î/, on the other hand, is not only uninfluenced by a preceding /q/, but causes the /q/ to surface as [k], as shown in (54).

      /qi/ → [qa]   based on Buckley's (12)
(53) sima·q-i   →   sima·qá   'sleep!'
      ʔusaq-in   →   ʔusá·qan   'while washing the face'

      /qî/ → [ki]   based on Buckley's (14)
(54) ʔusaq-îbic-ʔ   →   ʔusá·kibiʔ   'start to wash the face'
      micʰaq-îbic-ʔ   →   micʰakí·biʔ   'start mashing'

Because adding feature strength partly separates a segment's featural representation from its phonetic substance, it offers a way to distinguish between the two [i]s, in spite of the fact that they are identical phonetically. While both segments have the same feature values, [+high, -back, -low][20], they differ in that /î/ is strongly specified for at least [high] and [back]. This difference can be referred to by constraints that target segments strongly specified for a particular feature. For example, IDENT-IO$_S$(HI), defined in (55) only applies to vowels strongly strongly specified for the feature [high].

(55) IDENT-IO$_S$(HI) – Let X be a segment in the output that is strongly specified for the feature [high] and let Y be a correspondent of X in the input. If Y is [α high], then X is [α high].

Since /î/ is strongly specified for high, while /i/ is not, this constraint will only apply to /î/. Accordingly, if IDENT-IO$_S$(HI) is undominated it will prevent /î/, but not /i/, from surfacing as

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[20]I follow Buckley in using the features [high], [back], and [low] for the vowels of Kashaya.

any segment that is not also [+high]. This would account for the fact that /î/ never surfaces as [a], while /i/ does. Crucially, analogous explanations for the all of the differences between the two [i]s become possible with the addition of feature strength. IDENT-IO$_S$(BK) could be used to account for /î/ not mutating following [d], while a constraint prohibiting [q] from appearing before a vowel strongly specified for [high] could be used to drive the /q/ fronting to [k]. In other words, adding feature strength makes it possible to account for the different phonological behaviors exhibited by the two [i]s. This is important because Buckley's underspecification analysis is no longer applicable in OT.

The fact that the addition of feature strength is useful in accounting for differential behavior of phonetically identical segments offers nice support for the proposal because it is unrelated to the initial motivation for the change.

5   Discussion

In the previous sections, we saw that, in spite of apparent challenges, it is possible to account for both Khalkha rounding harmony and Finnish palatal harmony in ABC. What is more, no new type of constraint was needed to handle either of these systems. The fact that both of these systems can be analyzed with ABC in its basic form indicates that the model is capable of accounting for a wider variety of vowel harmony systems than was originally assumed. This raises the question of whether ABC should, if possible, be applied to all cases of vowel harmony. Since doing so would constitute an expansion of the coverage of ABC, it is important to first consider a pair of arguments that the scope of ABC should limited. Hansson (2001) argues that only consonant harmony, and not vowel harmony, should be analyzed as ABC. Gallagher (to appear) argues that the model's coverage should be even more limited; specifically, that it should only be used to account for total identity effects. I discuss each of these arguments in turn.

5.1   Hansson's argument

Accounting for vowel harmony with ABC would make it possible to give vowel and consonant harmonies a unified formal analysis. While there are reasons to favor unifying the formal analysis of cases of agreement between nonadjacent segments, Hansson (2001) argues that there are important differences between consonant and vowel harmonies that justify distinct analyses of the two phenomena. He focuses on three major areas of difference between the two types of harmony: directionality, segmental opacity, and sensitivity to prosodic structure.

According to Hansson, consonant harmony systems, unlike vowel harmony systems, have right-to-left directionality by default, lack blocking effects[21], and do not interact with things like stress or prosodic domains. Interestingly, the basic model of ABC, which was initially developed to account for consonant harmony systems, is not particularly well suited to account for any of these aspects of consonant harmony. The basic model of ABC does not generate any directionality by default. In order to generate left-to-right directionality, Hansson is forced to add targeted constraints (Wilson 2000, 2001) to the model. As for the lack of blocking effects, Hansson (2007) and I (§§3.3 and 3.4)

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[21] As mentioned in footnote 3, there are a few consonant harmony systems that exhibit blocking effects, so Hansson's claim that consonant harmony systems never include opacity is too strong. With that said, the fact that opaque segments are extraordinarily rare in consonant harmony systems, but quite common in vowel harmony systems, remains an important difference between the two.

have demonstrated that ABC is perfectly capable of generating blocking effects. Finally, Hansson (2001:Ch. 5) admits that he sees no way to rule out prosodically-bounded harmony in ABC, or any other type of analysis for that matter. Instead, he suggests that the lack of such harmony systems is probably best explained in terms of the diachronic development of consonant harmony systems. As for explaining the default left-to-right directionality and the lack of blocking effects, Hansson draws parallels between these aspects of consonant harmony and characteristics of speech errors. Based on these and other parallels, he suggests that consonant harmony systems have their origins in the speech planning domain. If this is right, it seems more appropriate to seek to explain the directionality and opacity differences in terms of the diachronic development of consonant and vowel harmony systems, rather than in terms of the synchronic grammar, just as Hansson suggests doing for the difference in sensitivity to prosodic structure. Explaining these differences in terms of differences in the origins of the two types of harmony removes the need to have separate synchronic accounts of the phenomena and, so, leaves open the possibility of analyzing vowel harmony as ABC.

5.2   Gallagher's argument

Gallagher claims that ABC should only be used to account for what MacEachern (1999) calls the TOTAL IDENTITY EFFECT. In languages that exhibit this effect, identical segments are free to cooccur within a root, while the cooccurrence of similar segments is disfavored. In order to limit the coverage of ABC, Gallagher proposes eliminating feature specific IDENT-SS constraints, such as IDENT-CC(VOI), in favor of a single IDENT-SS constraint, which compels corresponding segments to be identical. The argument for the limitation of ABC is based on the fact that, in its current form, ABC overgenerates in two ways. First, it predicts a variety of unattested single feature harmony patterns. Second, it predicts unattested gradient grammaticality patterns. I will address each of these issues in turn.

Gallagher correctly points out that deriving total identity effects in ABC using only feature specific IDENT-SS constraints leads to the prediction that a variety of unattested harmonies should exist. This is because a variety of otherwise unmotivated single feature IDENT-SS constraints are needed to account for total identity effects. For example, in the Mayan language Chol (Aulie & Aulie 1978, Coon & Gallagher 2007, Gallagher to appear), only identical ejectives may cooccur within a root. Since ejectives contrast for major place, stridency, and anteriority in this language, accounting for the total identity effect using only single feature IDENT-SS constraints requires IDENT-CC(PLACE), IDENT-CC(STRID), and IDENT-CC(ANT). The problem is that if IDENT-CC(PLACE) and IDENT-CC(STRID) exist, we expect to find single feature harmonies involving major place and stridency, but such harmonies are completely unattested (Hansson 2001). Clearly, total identity effects should not be accounted for using only single feature IDENT-SS constraints. However, this does not mean that single feature IDENT-SS constraints should be completely abandoned and that ABC should only be used to analyze total identity effects, not single feature harmonies.

Analyzing single feature harmonies instead exclusively as spreading of features leads the grammar to undergenerate, as Gallagher acknowledges. While most single feature harmonies involve features that could spread across intervening transparent segments with no audible effects, there are cases of laryngeal, nasal, and dorsal harmony that cannot be the result of featural spreading. In these laryngeal, nasal, and dorsal harmonies the agreement feature could not spread across intervening segments unnoticed. This undergeneration can be avoided if, rather than replacing single feature IDENT-SS constraints with a single constraint that requires complete identity, some single feature constraints are maintained alongside the full identity requiring constraint. In particular, those single

feature constraints needed to account for attested single feature harmonies would be maintained. By including the IDENT-SS constraint that requires full identity, this approach also avoids the overgeneration associated with deriving total identity effects using only feature specific constraints. Of course, a version of ABC that includes both single feature constraints and a total identity requiring IDENT-SS constraint is not as simple as one that includes only single feature constraints or the total identity requiring constraint. However, it is more important to be able to account for the full range of data than it is to have the most elegant theory.

Additionally, maintaining single feature constraints makes it possible to account for consonant harmonies without reference to feature spreading, which means that although ABC is less simple, less total theoretical machinery is necessary to account for consonant harmony. What is more, overall theoretical simplicity is not the only argument for accounting for single feature harmonies with ABC rather than feature spreading. As Hansson (2001:Ch. 6) shows, there are a number of parallels between speech errors and consonant harmony systems, including directionality (later segments are more likely to influence earlier segments) and the role of similarity (more similar segments are more likely to interact). Hansson focuses especially on the fact that both slips of the tongue and coronal harmonies show a 'Palatal Bias' (Stemberger 1991). In both speech errors and consonant harmony systems, alveolars, such as /s/ or /t/, are far more likely to be replaced with 'palatals', such as /ʃ/ or /tʃ/, than vice versa. Hansson argues that these parallels are evidence that speech errors, rather than the spread of gestures, are the diachronic source of consonant harmony systems, including coronal harmonies. If this is correct then it is more appropriate to analyze consonant harmonies as ABC, which is consistent with such a diachronic source, than as the spread of features, which is not.

Predicting unattested single feature harmonies is not the only problem with ABC that Gallagher discusses. She also argues that ABC as originally formulated predicts unattested patterns of gradient grammaticality, such as the one given in (56) (based on Gallagher's (20)).

(56)   Unattested pattern of grammaticality predicted by ABC[22]

Consonants	O/E	Violates
m-f	0	IDENT-CC(VOI), IDENT-CC(SON), IDENT-CC(CONT)
b-f	0.3	IDENT-CC(VOI), IDENT-CC(CONT)
m-p	0.3	IDENT-CC(VOI), IDENT-CC(SON)
b-p	0.7	IDENT-CC(VOI)
p-f	0.7	IDENT-CC(CONT)
m-b	0.7	IDENT-CC(SON)
m-m	1	none
b-b	1	none
p-p	1	none
f-f	1	none

This is problematic because in languages described so far the patterns of gradient grammaticality tend to look like the one reported in (57).

(57)   Cooccurrence of labials in the Austronesian language Muna (van den Berg 1989, Coetzee & Pater 2008)

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[22]O/E stands for Observed over Expected. This is a ratio of the number times a consonant pair was observed to cooccur to the number of times that pair would have been expected to cooccur by chance. An O/E value above 1 means that a consonant pair is overattested. An O/E value below 1 means that a consonant pair is underattested. For examples of the use of O/E and explanations of how it is calculated see Frisch *et al.* and Coetzee & Pater.

Consonants	O/E	Disagreeing Features
m-f	1.04	continuant, nasal, voice
b-f	0.58	continuant, voice
m-p	0.39	nasal, voice
b-p	0.10	voice
p-f	0.07	continuant
m-b	0.07	nasal
m-m	1.24	none
b-b	2.79	none
p-p	1.46	none
f-f	2.5	none

Notice that the predicted pattern in (56) and the attested pattern in (57) differ considerably, as illustrated in the graph (58)[23].

(58)

Predicted vs. attested grammaticality
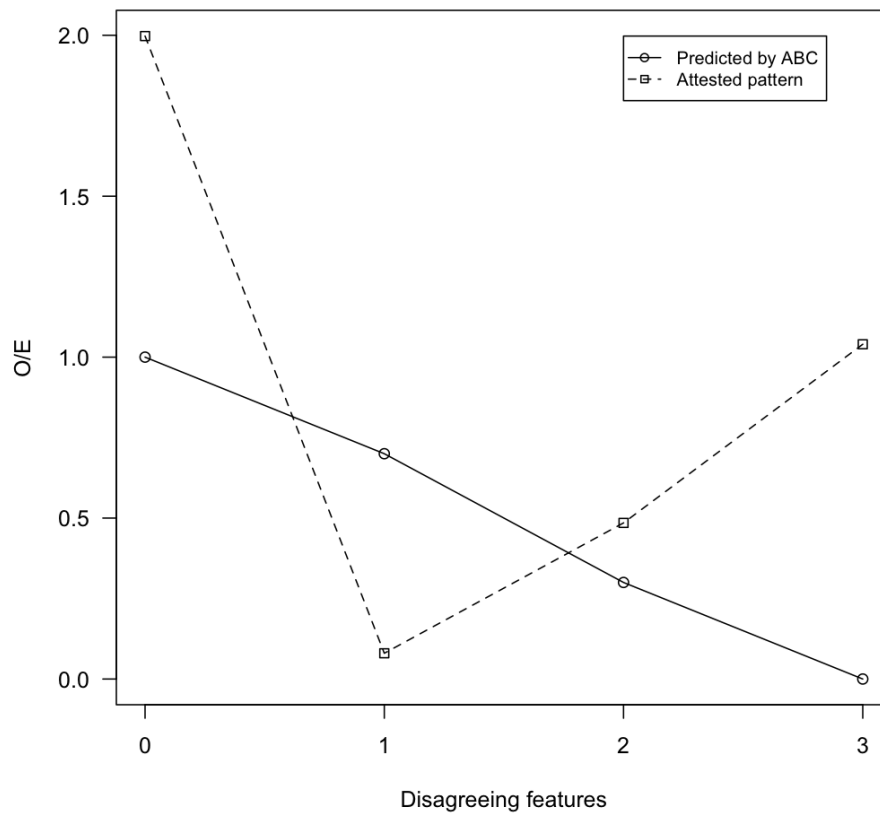
In (57) and (58), we see that the more similar two non-identical segments are (captured here by the number of disagreeing features), the less likely they are to cooccur. While this is not what is predicted by ABC (especially clearly illustrated in (58)), this is exactly what would be expected if

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[23]The O/E values for each number of disagreeing features on the attested line was determined by averaging the O/E values for each pair of consonants with the relevant number of disagreeing features.

these gradient grammaticality patterns are the result of the phonologization of speech error patterns. This is because segments that are more similar to each other are more likely to interact in slips of the tongue (see Hansson 2001, Ch.6 and references therein). If speech errors are the diachronic source of long distance consonant interactions, as Hansson argues, then it is unsurprising that we find gradient grammaticality patterns like the one in (57) rather than those like the one in (56). The idea being that a segment is more likely to be substituted for another segment if the two are more similar (have fewer disagreeing features) and gradually this greater likelihood of substitution would lead to a lower rate of cooccurrence of more similar pairs. If this extragrammatical influence of speech errors on the development of long distance consonant interactions overrides or even just obscures the influence of ABC constraints on the same development, that would explain why patterns like the one found in (56) are unattested.

While Gallagher brings up two legitimate issues for ABC as it was originally formulated, neither of the problems justifies narrowing the range of data that is analyzed as ABC. First, there is no need to stop analyzing single consonant feature harmonies as ABC in order to avoid predicting unattested single feature harmonies. This is because it is possible to avoid such overgeneration by simply eliminating unmotivated single feature IDENT-SS constraints from ABC and adding Gallagher's full identity requiring IDENT-SS constraint. This approach has the added benefit of avoiding the undergeneration that would result from treating all single feature consonant harmonies as featural spreading. It is also unnecessary to narrow the range of data accounted for by ABC to avoid predicting unattested patterns of gradient grammaticality if we are willing to accept Hansson's (2001) argument that the diachronic source of long distance consonant interactions is speech errors. If we accept Hansson's argument then we are free to assume that any potential effects that ABC constraints might have on the development of gradient grammaticality patterns are obscured by the influence of speech errors. This seems especially reasonable given that the effects we would expect based on tendencies in speech errors mirror reported gradient grammaticality patterns. It is crucial that neither of the problems that Gallagher raises force us to narrow the range of data covered by ABC because such a narrowing would rule out the possibility of extending ABC to vowel harmony. Since no such narrowing is necessary, there is nothing that prevents us from analyzing vowel harmony as ABC.

6 Conclusion

The analyses of Khalkha Mongolian rounding harmony and Finnish palatal harmony presented §§3 and 4 demonstrate that the basic model of ABC is able to handle diverse types of vowel harmony systems. The treatment of Khalkha shows that, contrary to Hansson's (2007) claim, it is possible account for an opaque segment that carries the harmonizing feature with ABC and doing so requires no addition to the model. The account of Finnish shows that, with the addition of feature strength to segmental representations, ABC offers a way to deal with cases of segmental transparency that have up to this point proved quite challenging in OT. The fact that ABC is able to handle these two relatively different systems without addition or modification suggests that the model might be applicable to all cases of vowel harmony. Analyzing vowel harmony as ABC has two major positive effects. First, it unifies the formal analysis of vowel and consonant harmonies. This makes it possible to explicitly account for the commonality between the two types of harmony: namely, the interaction between the nonadjacent segments. The second positive effect is that ABC offers a way to account for vowel harmony that does not require the assumption that agreement is the result of

strictly local feature spreading. This is important because it appears that at least some vowels are truly transparent (Kim 2005). That is to say, the relevant vowels occur between harmonic vowels agreeing for a feature, but they themselves carry the opposite feature value. Clearly, agreement between harmonic vowels across such transparent vowels cannot be the result of strictly local feature spreading, so the availability of an analysis that does not assume strict locality is crucial.

A   Local constraint evaluation

An ambiguity in the basic model of ABC is how IDENT-SS and CORR-SS constraints are evaluated: locally or globally. This ambiguity did not affect analyses of consonant harmony, but it is relevant in accounting for vowel harmony due to the fact that such systems often include opacity. This is because, as Hansson (2006b, 2007) showed, if IDENT-SS constraints are evaluated globally, ABC makes a number of pathological predictions about systems that include opaque segments.

Hansson (2007) showed that global evaluation of IDENT-SS constraints leads to the prediction that there should be segments that sometimes block harmony and sometimes do not, depending on the number and type of potential harmony targets surrounding them. This prediction can be illustrated with the constraint ranking in (59).

(59)   *EI/OI, CORR-OE ≫ IDENT-VV(RD) ≫ IDENT-IO(RD)

In tableaux (60) and (61), we see that, if IDENT-VV(RD) is evaluated globally, the ranking in (59) predicts that, when /ei/ occurs as the second segment in a series of five non-high vowels, whether it is transparent or opaque will depend on the underlying quality of the following non-high vowels. If more of the following non-high vowels are rounded underlyingly, /ei/ is predicted to be transparent, as shown in tableau (60). But if more of the following non-high vowels are unrounded underlyingly, /ei/ is predicted to be opaque, as shown in (61).

(60)   Adapted from Hansson (2007) (10)
Global evaluation of IDENT-VV(RD), Local evaluation of CORR-OE

/o…ei…o…e…o/		*EI/OI	CORR-OE	IDENT-VV(RD)	IDENT-IO(RD)
a.	$o_i…o_i…o_i…o_i…o_i$	*!			**
b.	$o_i…e…o_i…o_i…o_i$		*!*		*
c. ☞	$o_i…e_i…o_i…o_i…o_i$			****	*
d.	$o_i…e_i…e_i…e_i…e_i$			****	**!

(61)   Adapted from Hansson (2007) (10)
Global evaluation of IDENT-VV(RD), Local evaluation of CORR-OE

/o…ei…e…o…e/		*EI/OI	CORR-OE	IDENT-VV(RD)	IDENT-IO(RD)
a.	$o_i…o_i…o_i…o_i…o_i$	*!			***
b.	$o_i…e…o_i…o_i…o_i$		*!*		**
c.	$o_i…e_i…o_i…o_i…o_i$			****	**!
d. ☞	$o_i…e_i…e_i…e_i…e_i$			****	*

Because candidates (c) and (d) tie on the globally evaluated IDENT-VV(RD) in these two tableaux, whether the underlying diphthong is opaque or transparent depends both on the underlying quality of the following segments and the lower ranked IDENT-IO(RD). Comparing tableaux (60)

and (61), we see that global evaluation of IDENT-VV constraints predicts what Hansson (2007) calls "a bizarre majority rules effect", where the transparency or opacity of a potentially opaque segment is determined by the underlying quality of the majority of the other potential targets of harmony. This seems to be an undesirable prediction.

In tableau (62) we see that with the same constraint ranking /ei/ is predicted to be consistently transparent to harmony when it occurs as the third segment in a series of non-high vowels, even if the majority of the other segments are unrounded underlyingly.

(62)   Adapted from Hansson (2007) (11)
        Global evaluation of IDENT-VV(RD), Local evaluation of CORR-OE

/o...e...ei...e...e/		*EI/OI	CORR-OE	IDENT-VV(RD)	IDENT-IO(RD)
a.	$o_i...o_i...o_i...o_i...o_i$	*!			****
b.	$o_i...o_i...e...o_i...o_i$		*!*		***
c. ☞	$o_i...o_i...e_i...o_i...o_i$			****	***
d.	$o_i...o_i...e_i...e_i...e_i$			*****!*	*

The fact that global evaluation leads to the prediction that the transparency or opacity of a segment can depend on the number of potential harmony targets that precede and follow it is clearly problematic.

While Hansson (2007) only showed that global evaluation of IDENT-SS constraints leads to these problematic predictions, it turns out that global evaluation of CORR-SS constraints leads to the exact same predictions. This can be illustrated with the constraint ranking given in (63).

(63)   *EI/OI, IDENT-VV(RD) ≫ CORR-OE ≫ IDENT-IO(RD)

Tableaux (64) and (65) demonstrate that the same majority rules effect occurs with the global evaluation of CORR-OE as Hansson observed with global evaluation of IDENT-SS constraints.

(64)   Global evaluation of CORR-OE, Local evaluation of IDENT-VV(RD)

/o...ei...e...o...o/		*EI/OI	IDENT-VV(RD)	CORR-OE	IDENT-IO(RD)
a.	$o_i...o_i...o_i...o_i...o_i$	*!			**
b.	$o_i...e_i...o_i...o_i...o_i$		*!*		
c. ☞	$o_i...e...o_i...o_i...o_i$			****	*
d.	$o_i...e_j...e_j...e_j...e_j$			****	**!

(65)   Global evaluation of CORR-OE, Local evaluation of IDENT-VV(RD)

/o...ei...e...e...o/		*EI/OI	IDENT-VV(RD)	CORR-OE	IDENT-IO(RD)
a.	$o_i...o_i...o_i...o_i...o_i$	*!			**
b.	$o_i...e_i...o_i...o_i...o_i$		*!*		
c.	$o_i...e...o_i...o_i...o_i$			****	**!
d. ☞	$o_i...e_j...e_j...e_j...e_j$			****	*

Tableau (66) shows that with global evaluation of CORR-OE, like global evaluation of IDENT-VV(RD), leads to the prediction that /ei/ is consistently transparent when it occurs as the third segment in a series of non-high vowels, even if the majority of the other segments are unrounded underlyingly.

(66)   Global evaluation of Corr-OE, Local evaluation of Ident-VV(rd)

	/o…e…ei…e…e/	*ᴇɪ/ᴏɪ	Ident-VV(rd)	Corr-OE	Ident-IO(rd)
a.	$o_i\ldots o_i\ldots o_i\ldots o_i\ldots o_i$	*!			****
b.	$o_i\ldots o_i\ldots e_i\ldots o_i\ldots o_i$		*!*		***
c. ☞	$o_i\ldots o_i\ldots e\ldots o_i\ldots o_i$			****	***
d.	$o_i\ldots o_i\ldots e_j\ldots e_j\ldots e_j$			*****!*	*

No such problematic predictions are made if Ident-SS(VV) and Corr-VV constraints are both evaluated locally. In tableaux (67)-(69) we see that /ei/ is always predicted to be opaque with the constraint ranking in (63), if Corr-OE is evaluated locally.

(67)   Local evaluation of Corr-OE and Ident-VV(rd)

	/o…ei…e…o…o/	*ᴇɪ/ᴏɪ	Ident-VV(rd)	Corr-OE	Ident-IO(rd)
a.	$o_i\ldots o_i\ldots o_i\ldots o_i\ldots o_i$	*!			**
b.	$o_i\ldots e_i\ldots o_i\ldots o_i\ldots o_i$		*!*		
c.	$o_i\ldots e\ldots o_i\ldots o_i\ldots o_i$			**!	*
d. ☞	$o_i\ldots e_j\ldots e_j\ldots e_j\ldots e_j$			*	**

(68)   Local evaluation of Corr-OE and Ident-VV(rd)

	/o…ei…e…e…o/	*ᴇɪ/ᴏɪ	Ident-VV(rd)	Corr-OE	Ident-IO(rd)
a.	$o_i\ldots o_i\ldots o_i\ldots o_i\ldots o_i$	*!			**
b.	$o_i\ldots e_i\ldots o_i\ldots o_i\ldots o_i$		*!*		
c.	$o_i\ldots e\ldots o_i\ldots o_i\ldots o_i$			**!	**
d. ☞	$o_i\ldots e_j\ldots e_j\ldots e_j\ldots e_j$			*	*

(69)   Local evaluation of Corr-OE and Ident-VV(rd)

	/o…e…ei…e…e/	*ᴇɪ/ᴏɪ	Ident-VV(rd)	Corr-OE	Ident-IO(rd)
a.	$o_i\ldots o_i\ldots o_i\ldots o_i\ldots o_i$	*!			****
b.	$o_i\ldots o_i\ldots e_i\ldots o_i\ldots o_i$		*!*		***
c.	$o_i\ldots o_i\ldots e\ldots o_i\ldots o_i$			**!	***
d. ☞	$o_i\ldots o_i\ldots e_j\ldots e_j\ldots e_j$			*	*

Since local evaluation of Ident-SS and Corr-SS constraints avoids pathological predictions, I have elected to evaluate both types of constraints locally, rather than globally. Instead of building local evaluation into the definition of each Ident-SS and Corr-SS constraint, I will explain what I mean by local evaluation now and assume it throughout the paper.

When Ident-SS and Corr-SS constraints are evaluated locally, a segment is only compared to the nearest preceding and following relevant segments. For Ident-SS constraints, the relevant segments are corresponding segments. So in the output string $ab_i cd_i ef_i g$, an Ident-SS constraint only evaluates the pairs *b* and *d* and *d* and *f*. Crucially, the constraint would not evaluate the pair *b* and *f* because there is another corresponding segment, *d*, in between them. If the Ident-SS constraint were being evaluated globally, the pair *b* and *f* would also be evaluated.

For Corr-SS constraints, the relevant segments are segments of the type that the Corr-SS constraint is compelling to correspond. For example, in the output string *padag* Corr-KD is only

violated if p and d or d and g fail to correspond. Crucially, the constraint is not violated if p and g fail to correspond because there is another oral stop, d, in between them. If the CORR-KD were being evaluated globally, it would also be violated if p and g failed to correspond.

Note that, as Hansson demonstrated with IDENT-SS constraints, it is still possible to derive global effects with chains of local evaluation. For instance, in *padag*, since CORR-KD compels p to correspond with d and d to correspond with g, p and g are indirectly compelled to correspond. This means that local evaluation does not limit the range of agreement and correspondence effects that ABC can generate, it simply avoids undesirable predictions.

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