Agreement and Disagreement of Vowel Features: Mid Vowel Assimilation in Yanggu[*]

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This study proposes an Optimality-Theoretic account of Yanggu mid vowel assimilation, and demonstrates that the interaction of markedness constraints and harmony-related constraints provides a unified analysis. Within the framework of Optimality Theory (Prince and Smolensky 1993), assimilation and harmony can be treated as feature agreement within a phonological or morphological domain, and any feature disagreement or disharmony within the domain is attributed to the restrictions set by markedness constraints (Cole and Kisseberth 1994, 1995, Padgett 1995, 1996). The proposed constraint-based analysis of Yanggu mid vowel assimilation posits two subsyllabic domains for vowel feature harmony, shows how markedness constraints bar the creation of marked, non-structure-preserving or universally prohibited segments, and argues that the constraint-based approach is superior to the traditional rule-based analysis in which several different but apparently related assimilation rules must be postulated.

Key words: Optimality Theory, vowel, assimilation, Yanggu, Mandarin

1. Introduction

Within the framework of Optimality Theory (Prince and Smolensky 1993), assimilation can be treated as a type of constraint that requires the segments within a phonological or morphological domain to agree in some features, and any feature disagreement or disharmony within the domain is attributed to the restrictions set by markedness constraints (e.g. Cole and Kisseberth 1994, 1995, Padgett 1995, 1996). In this paper, I examine mid vowel assimilation in the Yanggu dialect of Shandong, as described in Dong (1985), and argue for an analysis in which markedness constraints actively interact with the harmony constraints that require vowel feature agreement within two subsyllabic domains. This formal characterization of Yanggu mid vowel assimilation accounts for vowel feature agreement with one unified type of constraints, enlists the independently needed markedness constraints to prevent the creation of marked, non-structure-preserving or universally prohibited segments, and therefore

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eliminates the need to posit several different but apparently related assimilation rules.

This paper is organized as follows. §2 compares mid vowel assimilation between Standard Mandarin and Yanggu Mandarin and discusses the problems faced by a rule-based analysis. The introduction of Optimality Theory and theoretical assumptions are given in §3, and the proposed constraint-based analysis of Yanggu mid vowel assimilation is presented in §4.

2. Mid vowel assimilation

Following Cheng (1973), Lin (1989) and others, I assume that underlyingly Standard Mandarin (SM) has only two nonhigh vowels: one mid central vowel and one low vowel. Based on the data given in Dong (1985), the Yanggu vowel system does not seem to differ from SM. The underlying vowel system in SM and Yanggu then have five phonemic vowels. (1)shows the features that define these vowels, with the redundant values unspecified, as suggested in Lin (1989, 1992, 1993).[1]

	i	ü	u	ə	a
high	+	+	+	-	-
low					+
back	-	-	+		
round	-	+	+		

In SM, the mid vowel agrees in backness and/or rounding with a postnuclear or prenuclear glide (cf. Cheng 1973, Lin 1989, Wang 1993, Wu 1994). As shown in (2), a mid vowel becomes a front vowel when next to a front glide (2a,c,e), and becomes a back rounded vowel when adjacent to a back rounded glide (2b,d).[2] When the mid vowel is flanked by both types of glides, the mid vowel assimilates to the postnuclear glide, as shown in (2f,g). SM mid vowel assimilation is well-studied and has generated many different analyses (e.g. Cheng 1973, Pulleyblank 1984, Lin 1989, 1998a, Wu 1994). Because of the uniform assimilation process in SM, it is often difficult to judge if one analysis is necessarily better than the other.

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[1] There has been much debate regarding the underlying vowels in SM and its related dialects. See Lin (1989) for a review. See also Wang (1993) and Wu (1994).

[2] In this paper, I ignore that fact that in an open syllable, the back rounded mid vowel [o] and the front mid vowel [e] are phonetically lax.

(2) SM mid vowel assimilation
    a. /pəi/   → [pey]   'cup'
    b. /kəu/   → [kow]   'dog'
    c. /piə/   → [pye]   'don't'
    d. /kuə/   → [kwo]   'wok'
    e. /çüə/   → [çɥe]   'to learn'
    f. /tuəi/ → [twey] 'correct'
    g. /tiəu/ → [tyow] 'to throw'

In comparison, Yanggu provides an interesting case in which mid vowel assimilation is non-uniform and asymmetrical, as shown in (3-4).[3] The examples in (3a-d) show that in Yanggu the mid vowel assimilates only to the front prenuclear glide and the back rounded postnuclear glide. That is, rounding/backing assimilation occurs only regressively while fronting assimilation occurs only progressively. Therefore, the mid vowel in (3e), which is preceded by the back rounded glide and followed by the front unrounded glide, does not undergo any assimilation. On the other hand, as in SM, if both regressive rounding/backing assimilation and progressive fronting assimilation may apply, regressive assimilation takes precedence over progressive assimilation as in (3f).

(3) Yanggu mid vowel assimilation
    a. /kəi/   → [kəy]   *[key]   'square'
    b. /xəu/   → [xow]   'monkey'
    c. /tiə/   → [tye]   'saucer'
    d. /tsuə/ → [tswə]   *[tswo]   'seat'
    e. /xuəi/ → [xwəy]   *[xwey] *[xwoy] *[xwöy]   'ash'
    f. /iəu/   → [yow]   *[yew]   *[yöw]   'oil'

What is most puzzling is that when the mid vowel is preceded by the front rounded glide, no fronting assimilation applies, as the example in (4) shows. The differences in mid vowel assimilation between SM and Yanggu are summarized in (5).

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[3] The data of Yanggu are based on the unaffixed rimes given in Dong (1985). I use [ə] for the mid unrounded vowel, which is transcribed as [ɤ] by Dong. These mid vowels, either assimilated or unassimilated, remain the same in an *er*-affixed form, while some low vowels surface as lax mid vowel [ɛ]. An analysis of vowel variation under Yanggu *er*-affixation is left for future research.

(4) Failure of fronting assimilation in Yanggu

/tçüə/   →   [tçɥə]   *[tçɥe]   *[tçɥö]   'lack'

(5) Mid vowel assimilation

SM: backing/rounding/fronting: both progressive and regressive

Yanggu: backing/rounding: regressive

          fronting: progressive

In a rule-based account of mid vowel assimilation in (2-4), one could formulate two general assimilation rules for each dialect, as given in (6-7).[4] The difference between Yanggu and SM then is that Yanggu assimilation is more restricted since it lacks progressive backing/rounding and regressive fronting.

(6) SM   a.   Regressive assimilation   b.   Progressive assimilation

V[-hi]   V[+hi]   V[+hi]   V[-hi]

[bk, rnd]   [bk, rnd]

(7) Yanggu   a.   Regressive backing/rounding   b.   Progressive fronting

V[-hi]   V[+hi]   V[+hi]   V[-hi]

[+bk, +rnd]   [-bk]

To account for examples like (2f,g) and (3f) where both regressive and progressive rules are applicable, such an analysis requires disjunctive order of the regressive assimilation rule before the progressive one. That is, regressive assimilation applies but progressive assimilation is blocked (cf. Cheng 1973, Lin 1989).

One problem immediately arises: the progressive rules in (6-7) wrongly predict that /üə/ would become *[ɥö] in SM and *[ɥe] in Yanggu. In fact, /üə/ undergoes fronting only in SM to yield [ɥe] (2e), and in Yanggu, /üə/ simply mysteriously fails to undergo any assimilation and surfaces as [ɥe] (4). For SM, one could suggest that rule (6b) has to be broken down into two rules as in (8). That is, progressive rounding applies only when the glide is [+back].

(8) SM: Two progressive assimilation rules

a.   V[+hi]   V [-hi]   b.   V[+hi]   V [-hi]

[+rnd, +bk]   [wo]   [-bk]   [ye], [ɥe]

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[4] The following abbreviations are adopted: [hi] for [high], [lo] for [low], [rnd] for [round], and [bk] for [back].

As for Yanggu, one could attribute the non-assimilation to the suggestion that the trigger of fronting assimilation is restricted to the unrounded front glide, as shown in rule (9).

(9)   Yanggu: revised progressive fronting assimilation rule

       V[+hi]   V [-hi]

         |

    [-rnd, -bk]   [ye]   but   [ɥə]
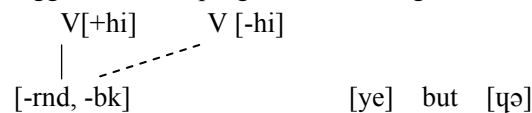
There are several technical and conceptual problems with this traditional type of analysis. First, it has the consequence of requiring binary values for [round]. Since [-round] does not seem to be phonologically active, most researchers have treated [round] as a privative feature (e.g. Steriade 1987, and articulator-based feature geometry in Sagey 1986, McCarthy 1988). An analysis that must refer to [-round] then becomes suspect.

Second, many unattested examples may be generated by the rule-based account. Rule reordering and further stipulations on the structure descriptions of the rules easily give rise to many unattested systems. For example, a system in which progressive assimilation takes precedence over regressive assimilation (e.g. [woy]) or only [+round] of a [-back] glide spreads while that of [+back] glide does not (e.g. [ɥo] or [ɥö] but [wə]) is, to my knowledge, at least unattested in Chinese.

Third, one clear generalization about all the processes of mid vowel assimilation in both SM and Yanggu involves the agreement of the vowel place features (or vowel harmony) within the domain of rime and that of the first demi-syllable (cf. Wu 1994, Lin 1998a, and §4 below). The rule-based approach, however, treats the apparently related processes as separate and seemingly unrelated ordered rules, and hence misses the generalization.

Fourth, reformulating the fronting assimilation rule as in (9) solves the technical problem but does not really explain why the front rounded and unrounded glides behave differently. Feature disagreement then appears to be accidental since it is not attributed to any phonological or phonetic principle. One could try to improve the situation by suggesting that only general spreading rules such as (6-7) are postulated and the failure of rounding assimilation in SM [ɥe], for example, is attributed to structure preservation (Kiparsky 1982, 1985), which blocks the creation of [ö], an unattested sound in SM (cf. Lin 1989). However, for Yanggu, no such explanation is available. Since [e] is readily acceptable, as is evident in the example [ye], one expects fronting assimilation to produce [e] after the front rounded glide, and yet [e] is not allowed to surface in the case of [ɥə].

Mandarin mid vowel assimilation then illustrates that a model in which assim-ilation rules can be formulated in many different ways without clear motivations is too powerful and overgenerates unattested patterns. In what follows, I propose a constraint-based analysis of the Yanggu data, and demonstrate that both the regular and exceptional patterns can be accounted for by the same set of well-motivated con-straints.[5]

3. Theoretical assumptions

The analysis proposed in this paper is cast within Optimality Theory (OT) (Prince and Smolensky 1993), and the idea of interaction of markedness and feature class assimilation is based on Feature Class Theory (FCT) as outlined in Padgett (1995, 1996). In (10), I list the central tenets of OT.

(10) Optimality Theory
    a. UG provides a set of constraints that are universal and universally present in all grammars.
    b. Constraints are violable; but violation is minimal.
    c. The constraints are ranked on a language-particular basis. A grammar is a ranking of the constraint set.
    d. The constraint hierarchy evaluates a set of candidate analyses that are admitted by very general considerations of structural well-formedness.
    e. Best-satisfaction of the constraint hierarchy is computed over the whole hierarchy and the whole candidate set. There is no serial derivation.

As illustrated in (11), given an input k, a ranked constraint set, in which constraint A is ranked higher than constraint B and constraint B higher than constraint C, evaluates all the possible output candidates of k.

(11) Given the constraint ranking   A >> B >> C, and input k, k-cand$_3$ is the optimal output.

Input: k	A	B	C
k-cand$_1$	* !		
k-cand$_2$		* !	
☞ k-cand$_3$			*

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[5] For an OT analysis of SM vowel assimilation see Lin (1998a), and for a discussion of mid vowel assimilation in other Mandarin dialects, see Lin (1998ab).

A candidate that violates a high-ranking constraint is fatal and cannot be optimal. A fatal violation is marked with the symbol '!', after which any violations of the lower ranked constraints are irrelevant and those table cells are shaded. The optimal output is indicated by the pointing hand. The first two candidates in (11) are ruled out because they violate the higher ranked constraints, although neither of them incurs a violation of C. The third candidate is selected as the optimal output because it violates only the lowest ranked constraint.

In Feature Geometry (see McCarthy 1988, Clements and Hume 1995), those features that pattern together are grouped into a constituent dominated by a class node. In FCT, minimal hierarchical structure is assumed: the root node, which contains [son], dominates all features in a flat structure, and the coronal feature dominates [anterior] and [distributed] (Padgett 1995). All features are grouped into feature classes in a 'semantic' nonrepresentational way, e.g.:

(12) Vocalic Place: {high, low, back, round}
      Height: {high, low}
      Color: {back, round}

Based on the OT tenet that constraints are violable but violation is minimal, Padgett claims that when a feature class is targeted by a constraint, all members within the class are individually affected, thereby allowing gradient violations. Partial assimilation is therefore derived by ranking segmental markedness constraints and/or other well-formedness constraints higher than assimilation-related constraints. That is, assimilation is partially enforced to avoid marked segments and structures. For example, Turkish color harmony is partially enforced due to a higher ranked constraint that prohibits rounded nonhigh vowels except in the initial syllable, as shown in (13a). Because of this higher ranked constraint, the feature [round] is associated to both vowels in (13b), but only to the initial vowel in (13c) (see Padgett 1995 for more details).

(13) a.   *[+rnd] noninitially >> color harmony
      b.   /sAnIn/   →   [sonun]
            rd, bk   \/
                          [rd,bk]
      c.   /sAndAn/ →   [sodan]
            rd,   bk   /\|
                          rd,   bk

The proposed analysis of Yanggu vowel assimilation also draws on the insights of Cole and Kisseberth's (1994, 1995) Optimal Domains Theory which requires uniform realizations of a harmony feature on all segments within a well-defined domain. Disharmony occurs when feature cooccurrence constraints are ranked higher than and clashed with the harmony-related constraints. Formally, harmony is not modeled as autosegmental spreading but as alignment constraints that require edge matching of phonological and morphological categories (McCarthy and Prince 1993). For example, to account for Pulaar [ATR] harmony, Cole and Kisseberth posit alignment constraints to determine optimal harmony domains, a feature realization constraint to express the [ATR] feature, and a feature cooccurrence constraint to prevent [ATR] from being realized on a low vowel (see Cole and Kisseberth 1994 for details). For the purposes of this study, I assume a simplified formulation as in (14), in which feature alignment requires that a feature be realized on every segment within a phonological or morphological domain (cf. Padgett 1995, 1996).

(14)   Align (F, Edge; Cat, Edge)
       Align a feature to both edges of a phonological or morphological category.
       (Cat = phonological or morphological categories, such as mora, syllables, word, stem, etc.)

Following Inkelas' (1995) proposal that underspecification applies only when there are alternant surface forms that are predictable from context or grammatical defaults, I assume that underlying Mandarin mid and low vowels are unspecified for [back] and [round] since all surface alternants of these two vowels result either from assimilation or default specifications. I also adopt the vowel features used in the feature theory of Clements and Hume (1995), and assume the feature classes as in (15).[6] The division of the V-place features from the aperture features intends to capture the co-patterning of [round]/[back] independent of vowel height (Odden 1991).

(15)   Vocalic place: {hi, lo, V-pl-lab, V-pl-cor, V-pl-dor}
       V-place: {V-pl-lab, V-pl-cor, V-pl-dor} (i.e. {+rnd, -bk, +bk})
       Aperture: {hi, lo}

As for the harmony domain, I divide the syllable into two demi-syllables as in Clements (1990) and consider these two subsyllabic domains as legitimate

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[6] The following abbreviations are used: V-pl-lab for V-place-labial, V-pl-cor for V-place-coronal, and V-pl-dor for V-place-dorsal.

phonological categories for feature alignment.[7] For convenience, I call the first demi-syllable the minimal syllable (cf. Wu 1994), and the second the rime.

(16) first demi-syllable = onset + nucleus = minimal syllable
      second demi-syllable = nucleus + coda = rime

For ease of presentation, I use segments rather than features to formulate markedness constraints. For example:[8]

(17) *ö = *[V-pl-lab, V-pl-cor, -hi] (i.e. *[+rnd, -bk, -hi])

I assume that there are some universal segmental markedness hierarchies similar to the sonority hierarchies proposed by Prince and Smolensky (1993). For example, given that [ö] and [ë] are less common cross-linguistically, the constraints in (18a) are ranked higher than those against the more common vowels [o] and [e] in (18b), which in turn are ranked higher than the constraints against the most common vowels in (18c).

(18) Segmental markedness hierarchy
      a. *ë, *ö >> b. *o, *e >> c. *i, *u, *a, *ɔ

The specific ranking between the constraints at the same level, e.g. between *o and *e, is an empirical question and requires further investigation. As we will see below, at least in Yanggu, it is necessary to rank *o above *e. Unlike the less controversial sonority hierarchies, it is not clear what a universal segmental markedness hierarchy may be like. Lin (1996) points out that one single hierarchy may not be feasible and we

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[7] In Clements (1990), the notion of demi-syllables has been used successfully to account for the different sonority profiles of the demi-syllables: maximum sonority distance between the onset and nucleus and minimum sonority distance between the nucleus and coda. The moraic representation of Hyman (1985) and Zec (1994) groups the onset and nucleus under one mora, making it possible to refer to the first demi-syllable as the first mora or the strong mora of the syllable. Wu (1994) also makes use of demi-syllables in her analysis of Standard Mandarin segmental phonology. Whether or not other Chinese dialects refer to demi-syllables in phonological processes require further investigation.

[8] The markedness constraints in the form of feature cooccurrence restrictions are similar to the marking conditions that prohibit the creation of non-underlying feature combinations or structure (structure preservation in Kiparsky 1982, 1995). In an output-oriented model like OT where constraints are violable, whether or not a structure is allowed to surface in a particular language is not absolute but depends on the relative ranking of the markedness constraints with respect to other constraints. Violation of structure preservation is then possible in this model. See Lin (1995, 1996) for examples and discussion.

need much more empirical evidence before we can settle the issue. For the task at hand, I adopt the tentative universal ranking as in (18), and assume that the ranking of the constraints at each level, e.g. between *o and *e or between *i, *u, *a, and *ɔ, may vary cross-linguistically.

4. Proposed analysis of Yanggu mid vowel assimilation

I propose an analysis of Yanggu mid vowel assimilation in which feature agreement and disagreement result from the interactions between the harmony constraints that require feature agreement within a phonological domain and the markedness constraints that eliminate marked and/or non-structure-preserving feature combinations or segments.

Based on the assumptions given in the previous section, the feature specifications of the five vowels are given in (19), and the harmony constraints in Yanggu are formulated as in (20).

(19)　　/i/:　[V-pl-cor]
　　　　/u/:　[V-pl-lab, V-pl-dor]
　　　　/ü/:　[V-pl-lab, V-pl-cor]
　　　　/ə/　[-hi, -lo]　　　(unspecified for V-pl features)
　　　　/a/　[+lo]　　　　(unspecified for V-pl features)

(20)　a.　Rime harmony:
　　　　　Align-Vlab-rime: Align (V-pl-lab, edge; rime, edge)
　　　　　Align V-pl-lab to both edges of a rime.
　　　　　(The segments within the rime agree in rounding)
　　　b.　Minimal syllable (first demi-syllable) harmony:
　　　　　Align-Vpl-α_m:　(V-pl, edge; minimal α, edge)
　　　　　Align all V-place features to both edges of the minimal syllable.
　　　　　(The segments within the first demi-syllable agree in backness and rounding)

Since constraints holding within the rime are more common than those between the onset and the nucleus (e.g. Selkirk 1982, 1984, Levin 1985, Fudge 1987) and the segments within the rime are preferred to have less sonority distance than those between the onset and the nucleus (Clements 1990 and references therein), I propose that rime harmony is universally ranked higher than first demi-syllable harmony, as shown in (21). This harmonic ranking accounts for the fact that regressive assimilation takes precedence over progressive assimilation.

(21) Harmonic ranking:
rime harmony >> minimal syllable harmony

The harmony constraints in SM and Yanggu are different in that rime harmony in SM involves all V-place features (Lin 1998ab) while Yanggu rime harmony must be restricted to rounding; otherwise, a ranking paradox would arise as we will see below. Recall that in Padgett's account of harmony, assessment of harmony constraints is gradient since individual features of a feature class are individually targeted, resulting in partial assimilation. In support of Padgett's proposal, I have demonstrated elsewhere (Lin 1998b) that violations of minimal syllable harmony in SM and Lanzhou Mandarin, and violations of rime harmony in Jinan Mandarin must be assessed gradiently. Yanggu, however, does not seem to require gradient assessment of the harmony constraints. Since rime harmony in Yanggu involves only one feature, the issue of gradient versus categorical constraint assessment does not arise. As we will see below, gradient assessment of minimal syllable harmony in Yanggu fails to select the attested output for /üə/. I postpone the discussion of the crucial example and assess the violations of Yanggu harmony constraints categorically in the following presentation. Categorical assessment of the minimal syllable harmony means that regardless of the extent to which the harmony constraint is violated, only one violation mark is incurred.

Consider first the simple examples in which only one glide occurs. Recall that Yanggu mid vowel assimilation is asymmetrical in that rounding/backing occurs only regressively, i.e. [ow] but [wə], and fronting applies only progressively, i.e. [ye] but [əy]. Tableau (22) illustrates the effect of rounding assimilation and the lack of fronting in the rime, providing evidence that rime harmony must be ranked higher than segmental markedness constraint *o. The mid vowel of the first candidate in (22a) does not bear the V-place-labial feature, violating rime harmony; that is, the two segments in the rime do not agree in rounding. Since the mid vowel is unspecified for backness, a rounded mid vowel may be either a front rounded vowel or a back rounded vowel.[9] If *ö is universally ranked higher than *o, as assumed in (18), the candidate with a front rounded vowel cannot be optimal, hence resulting in the selection of [ow] as the optimal output.[10] Rime harmony, on the other hand, is irrelevant for the example in (22b) since there is no V-place-labial feature in the input. The lack of assimilation thus results from the markedness constraint against [e].

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[9] Due to the lack of a rounded central vowel that is unspecified for backness, I have to assume that any rounded mid vowel is realized as either [-back] or [+back].

[10] The constraints *ö and Align-Vlab-rime are not crucially ranked with each other, as indicated by the dotted line between them.

(22) Mid vowel with a postnuclear glide

   a. Align-Vlab-rime >> *o

      *ö >> *o

əu	*ö	Align-Vlab-rime	*o
əw		*!	
öw	*!		
☞ ow			*

b.

əi	Align-Vlab-rime	*e
☞ əy		
ey		*!

The fact that *e bars the occurrence of [e] in (22b) does not mean [e] is never allowed to surface in Yanggu. Since these constraints are violable and the effects of a particular constraint depend on how it interacts with other constraints, we expect that if a constraint that demands an [e] vowel is ranked higher than *e, this vowel would surface. This is exactly what happens in (23a), which shows that in order to account for fronting assimilation, minimal syllable harmony must be ranked higher than *e. When the mid vowel follows a front glide, minimal syllable harmony becomes active and selects the candidate that undergoes assimilation. On the other hand, *o must be ranked higher than minimal syllable harmony to account for the lack of rounding assimilation in the example of (23b).

(23) Mid vowel with a prenuclear glide

   a. Align-Vpl-σ_m >> *e

iə	Align-Vpl-σ_m	*e
yə	*!	
☞ ye		*

b. *ö >> *o >> Align-Vpl-σ_m

uə	*ö	*o	Align-Vpl-σ_m
☞ wə			*
wö	*!		*
wo		*!	

The examples we have seen show that feature disagreement stems from the active effect of markedness constraints and their interaction with the harmony constraints. In

(22b) where the harmony constraint is irrelevant, the markedness constraint determines the optimal output. When markedness constraints outrank the relevant harmony constraint, as in (23b), markedness consideration would tolerate disharmony in order to avoid creation of relatively marked nonphonemic vowels.

The constraint rankings we have established is summarized in (24). All of these constraints can then be combined into one single ranking with no ranking paradox, as shown in (25).

(24) Universal harmonic rankings

    a.   Align-Vlab-rime >> Align-Vpl- σ_m (21)
        (i.e. rime harmony >> minimal syllable harmony)
    b.   *ö >> *o   (18)

Language specific rankings

    c.   Align-Vlab-rime >> *o   (22a)
    d.   Align-Vpl- σ_m >> *e   (23a)
    e.   *o >> Align-Vpl- σ_m (23b)

(25) Constraint ranking for Yanggu mid vowel assimilation
    * ö, Align-Vlab-rime >> *o >> Align-Vpl- σ_m >> *e

The tableaux in (26) show that the constraint ranking in (25) leads to correct results for the examples where the mid vowel is flanked by two glides. The conflicting demands of both harmony constraints are resolved by giving priority to rime harmony, which, as mentioned earlier, can be explained by the cross-linguistic generalization that rime harmony is a less marked and more general process. The ranking of rime harmony above minimal syllable harmony then successfully accounts for (26a) in which the candidate that undergoes regressive but not progressive assimilation is selected. The first and second candidates in (26a) are ruled out because they violate the higher ranked rime harmony constraint that demands rounding agreement, and the third candidate violates the markedness constraint against a front rounded mid vowel. The interesting asymmetrical assimilatory behavior between [yow] and [wəy] can also be accounted for by the same ranking. As shown in (26b), the rimes of the second and third candidates do not agree in rounding, and hence cannot be optimal due to the high-ranking Align-Vlab-rime. The first and fourth candidates, [wəy] and [wey], are tied after the evaluation of minimal syllable harmony. When other things being equal, the markedness constraint *e eliminates the candidate with a mid front vowel and favors the occurrence of the input vowel (cf. (22b)).

(26) Mid vowel flanked by two glides

a.   rime harmony >> minimal syllable harmony

iəu	*ö	Align-Vlab-rime	*o	Align-Vpl-σ_m	*e
yəw		*!		*	
yew		*!			*
yöw	*!			*	
☞ yow			*	*	

b.   *e disfavors the occurrence of [e].

uəi	*ö	Align-Vlab-rime	*o	Align-Vpl-σ_m	*e
☞ wəy				*	
woy		*!	*		
wöy	*!	*!		*	
wey				*	*!

Recall that in a rule-based approach, the total failure of assimilation when the mid vowel is preceded by a front rounded glide is unexpected and requires undesirable stipulations and modifications of the progressive fronting rule. The tableau in (27) shows that the same ranking of the same set of constraints as motivated by the simple cases in (22) and (23) correctly selects the attested output. The first and third candidates are tied after the evaluation of minimal syllable harmony and again the markedness constraint *e rules out the candidate with [e], accounting for the lack of fronting assimilation.

(27) Mid vowel preceded by /ü/

üə	*ö	Align-Vlab-rime	*o	Align-Vpl-σ_m	*e
☞ ɥə				*	
ɥö	*!				
ɥe				*	*!

Note that it is crucial for minimal syllable harmony to be assessed categorically; otherwise, as shown in (28), the wrong output would be selected. The first candidate in (28a) incurs two violation marks because the mid vowel does not agree with the glide in two features: V-pl-lab and V-pl-cor; on the other hand, in the third candidate, the mid vowel disagrees with the glide in only one feature. Based on a survey of mid vowel assimilation in five Mandarin dialects, Lin (1998b) has suggested that gradient versus categorical assessment of some constraints can be subject to cross-linguistic parametrization. The categorical assessment of a feature class captures class node

assimilation in traditional feature geometry, while gradient assessment is needed to account for typical cases of partial assimilation (Padgett 1995, 1996).[11]

(28) Wrong output for /üə/ if Align-Vpl- α_n is gradiently assessed

üə	*ö	Align-Vlab-rime	*o	Align-Vpl- α_n	*e
ɥə				*!*	
ɥö	*!				
☞ ɥe				*	*

For the success of the proposed analysis, it is also crucial that rime harmony is restricted to rounding. If rime harmony also refers to fronting, we would run into a serious ranking paradox. As shown in (29), if Yanggu rime harmony refers to the feature class V-place, then *e must be ranked higher than rime harmony as in (29a) (cf. (22)).

(29) Rime harmony refers to V-place
     a.   *e   >>   Align-Vpl-rime

əi	*e	Align-Vpl-rime
☞ əy		*
ey	*!	

     b.   Wrong output if Align-Vpl-rime   >> *e

əi	Align-Vpl-rime	*e
əy	*!	
☞ ey		*

Tableau (30) (= tableau (23a)) shows that for the example in which the mid vowel is preceded by the front glide, minimal syllable harmony must outrank *e. Since rime harmony must be ranked higher than minimal syllable harmony to account for the priority of regressive assimilation as in (26a), by transitivity, we expect that *e is also outranked by rime harmony, as shown in (31a). This conclusion, however, contradicts the need to rank *e higher than Align-Vpl-rime as demonstrated by the tableau in (29a).

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[11] In the OT literature not much has been discussed as to what types of constraints can be or should be categorically or gradiently assessed. Whether parametrization of the mode of assessment can be supported by other language data requires more research.

(30) Align-Vpl- α_n >> *e

iə	Align-Vpl- α_n	*e
yə	*!	
☞ ye		*

(31) Ranking paradox

    a.   Align-Vpl-rime >> *e

        (because Align-Vpl-rime >> Align-Vpl- α_n (26a) & Align-Vpl- α_n >> *e (30))

    b.   *e >> Align-Vpl-rime (29a)

Whenever there is a ranking paradox, a grammar cannot be properly defined. By restricting rime harmony to rounding, the proposed analysis avoids the problem.[12] Since assimilation does not always involve a feature class, such an analysis correctly allows the theory to account for many cases of assimilation that involves only one single feature.[13]

The proposed OT analysis successfully accounts for the non-uniform and asymmetrical behavior exhibited by Yanggu mid vowel assimilation, and has several advantages over the rule-based analysis discussed in §2. First, the analysis captures the generalization that mid vowel assimilation in Yanggu, just like that in SM (Lin 1998a) and many other vowel harmony systems, involves feature agreement within well-defined domains.

Second, the dominance of regressive assimilation over progressive assimilation is not stipulated as disjunctively ordered rules but attributed to a universal harmonic ranking that reflects the close ties between the segments within the rime.

Third, all regular and exceptional patterns of assimilation are accounted for by the same ranking of the same set of constraints, and partial assimilation or non-assimilation occurs when higher ranked constraints against marked feature combinations are at stake, resulting in exceptional feature disagreement. The need to posit a binary [round] feature and to formulate several seemingly unrelated ordered rules is then obviated.

Fourth, since constraints are ranked and violable, the effects of structure

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[12] To account for the fact that in Yanggu, /iəŋ/ surfaces as [yɔŋ] rather than [yeŋ], one may have to restrict rime harmony to backing rather than rounding as proposed here. Mandarin mid vowel variation in syllables closed with a nasal awaits further investigation.

[13] The suggestion that rime harmony may refer to different features in different languages seems to create complications by allowing language particular formulation of constraints. Note, however, that rime harmony is formulated in terms of generalized alignment, which allows a language to provide specific arguments within a universal alignment schema (McCarthy and Prince 1993).

preservation or segmental markedness restrictions may be manifested in some examples but not in others. Constraint interaction then explains why the surface realization of [e] in Yanggu is sometimes allowed but sometimes prohibited.

Finally , the ranking of the constraints consists of universal ranking hierarchies, such as the ranking between the two harmony constraints and that between the segmental markedness constraints, and the independently motivated language particular ranking between markedness and harmony constraints. The possibility of over-generating unattested grammars can then be greatly reduced since typological differences are attributed only to variation in language particular constraint ranking. Permutations of the constraints we have discussed may give rise to the following types of grammar:

(32) Factorial typology

    a.   *ö >> *o, *e   >> rime harmony >> minimal syllable harmony
           no assimilation
           e.g. Jiyuan

    b.   *ö >> *o >> rime harmony >> minimal syllable harmony   >> *e
           non-uniform and asymmetrical assimilation: lack of rounding/backing
           e.g. Jinan

    c.   *ö, rime harmony >> *o >> minimal syllable harmony   >> *e
           non-uniform and asymmetrical assimilation: lack of progressive rounding/backing
           e.g. Yanggu

    d.   *ö   >> rime harmony >> *o >> minimal syllable harmony   >> *e
           non-uniform and asymmetrical assimilation: lack of progressive rounding/backing
           e.g. Lanzhou

    e.   *ö >> rime harmony >> minimal syllable harmony   >> *o, *e
           uniform and symmetrical assimilation with partial assimilation in [ɥe]
           e.g. SM

    f.   rime harmony >> minimal syllable harmony   >> * ö   >> *o, *e
           uniform and symmetrical assimilation without exception

    g.   *ö, rime harmony >> *e >> minimal syllable harmony   >> *o
           non-uniform and asymmetrical assimilation: lack of progressive fronting

    h.   *ö >> *e >> rime harmony >> minimal syllable harmony   >> *o
           non-uniform and asymmetrical assimilation: lack of fronting

My study of mid vowel assimilation in SM and other Mandarin dialects has demonstrated that the grammars in (32a-e) are all attested. In Jiyuan (type 32a), no assimilation applies and the mid vowel remains as mid central, in Jinan (type 32b) only fronting assimilation applies, and in Lanzhou (type 32d), there is regressive but not progressive rounding/backing.[14] Yanggu discussed in this paper belongs to type (32c), and SM is a case of type (32e). I have not yet found a Mandarin dialect that has the grammar in (32f), and yet this grammar captures the typical language where assimilation occurs with no exceptions, which is certainly not an impossible language type. The grammars in (32g,h) are those for which attested languages are likely to be found since there are languages that allow only rounding but not fronting assimilation.[15] In contrast, in a rule-based model where both rule ordering and individual rules are language specific, there can be almost unlimited stipulations in rule formulation and ordering, and many unattested grammars would thus be generated.

4. Conclusion

In conclusion, this study has suggested that the asymmetrical nature of Yanggu mid vowel assimilation is not attributed to arbitrary rule formulation and rule ordering but explained by the interactions of feature agreement within subsyllabic domains and the universal segmental markedness constraints. The success and the advantages of the proposed analysis not only show that local assimilation, like long distance harmony, can be viewed as feature agreement within a well-defined phonological or morphological domain, but also lend further support to the growing body of studies in recent years demonstrating the important role played by constraint interaction and the need to motivate phonological processes with general phonological and phonetic principles.

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[14] For the details about the data and analysis of each dialect, see Lin (1998ab). The Jiyuan data come from He (1981) and Lanzhou and Jinan data from Yuan (1960).

[15] A full discussion of the details and consequences of the factorial typology of (32) is beyond the scope of this paper. I am in the process of collecting more Chinese dialect data to further confirm the predictions of (32), and issues related to (32) will be addressed in a separate paper.

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