

Contrast Preservation in Mandarin R-Suffixation

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Background: Rhyme Harmony

- In Mandarin Chinese, the low vowel /a/ has three surface forms:

(1)	ALLOPHONE	ENVIRONMENT	EXAMPLE	ENGLISH
(a)	Front [a]	Before alveolar nasal	[kʰan]	'threshold'
(b)	Central [ɑ̃]	In open syllable	[pɑ̃]	'handle'
(c)	Back [ɑ̄]	Before velar nasal	[tʰɑ̄ŋ]	'soup'

R-suffixation, or *Erhua*

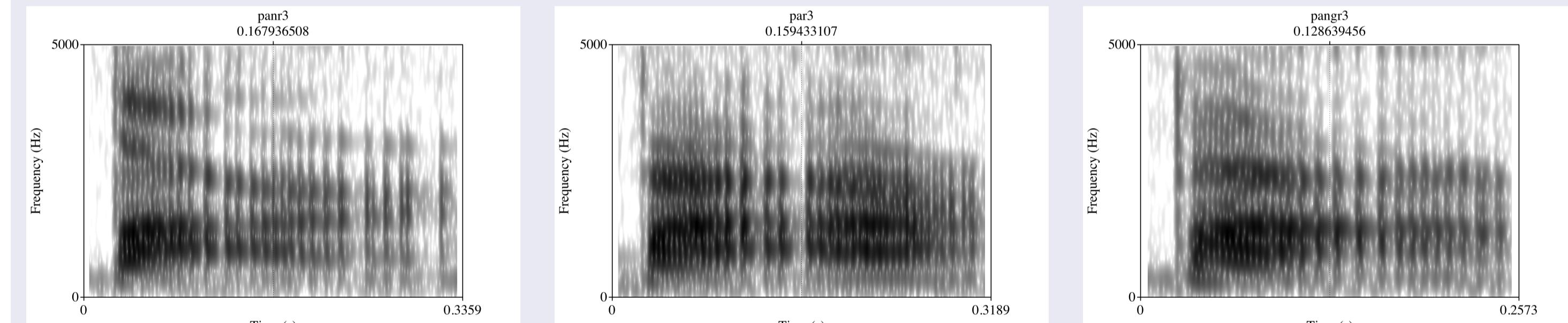
- A diminutive suffix /-r/ can be added to noun stems in many northern dialects of Mandarin.

(2)	STEM	ENGLISH	DIM	ENGLISH	NASAL STOP	V	Vowel
(a)	[kʰān]	'threshold'	[kʰar]	'threshold.DIM'	Dropped	Lost	Backed
(b)	[pɑ̃]	'handle'	[pɑ̄r]	'handle.DIM'	—	—	Backed
(c)	[tʰɑ̄ŋ]	'soup'	[tʰɑ̄r]	'soup.DIM'	Dropped	Kept	Stayed

- Zhang (2000): In stem forms, the velar nasal nasalizes the preceding vowel more than the alveolar nasal (longer duration of nasalization on the vowel): [ān] vs. [āŋ]
- In the Beijing dialect, the stems [ān] and [ɑ̄] are neutralized after r-suffixation
- Zhang uses this case to rule out a contrast preservation analysis

Liaoning Dialect

- Dialect of Mandarin spoken in the northeastern province of Liaoning
- Minimally different from Beijing Mandarin to its south
- Liaoning speakers can reliably produce and perceive the distinction between the suffixed form of [pān] and [pɑ̄]. How?
- Examining the acoustic data collected from three native female speakers:
- Spectrograms of the forms /pan+r/, /pa+r/, and /pan+r/ from one speaker, all in the third tone:



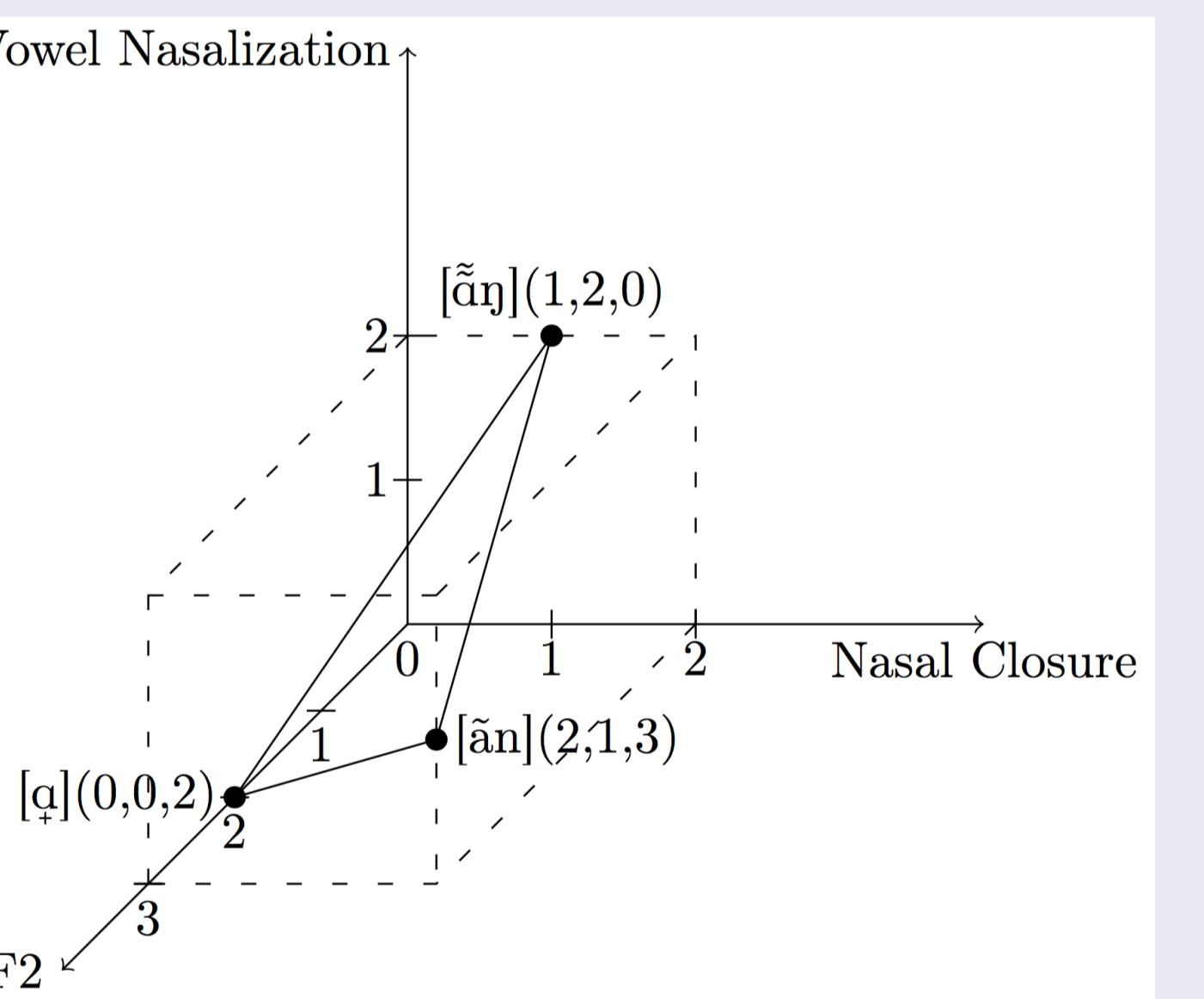
- F2 of the low vowel?
 - No significant difference in F2 between /an+r/ and /a+r/ forms ($t = -1.580$)
 - But F2 of both forms decreased from the stem form to the suffixed form
- Formant transition into the /-r/ coda?
 - In /an+r/, F2 rises and F1 lowers, starting from early in the rhyme
 - But in /a+r/ and /an+r/, F2 and F1 are stable throughout most of the rhyme
 - Verified in a linear mixed-effect model of 77 tokens:
 - The F2-F1 gap at rhyme end is significantly greater in /an+r/ than /a+r/ ($t = 6.148$)
 - F2 increase from rhyme start to end is significantly greater in /an+r/ than in /a+r/ ($t = 4.867$)
 - Neither measure is significant between /a+r/ and /an+r/ ($t = 1.455$, $t = 1.885$)
- Two /-r/ allophones:
 - The regular [-ɹ]: /a+r/ → [ɑ̄] and /an+r/ → [āŋ]
 - The retroflex [-ɻ]: /an+r/ → [āɹ]
- Jiang, Chang, & Hsieh (2019) have shown in an EMA study of the Liaoning dialect that
 - The tongue gesture of /-r/ after monophthong stems is different from the monomorphemic [-ɹ]
 - The former involving tongue body, and the latter the tongue tip.
- It is possible that they correspond to the [-ɹ] and [-ɻ] here, respectively.

Contrast Preservation

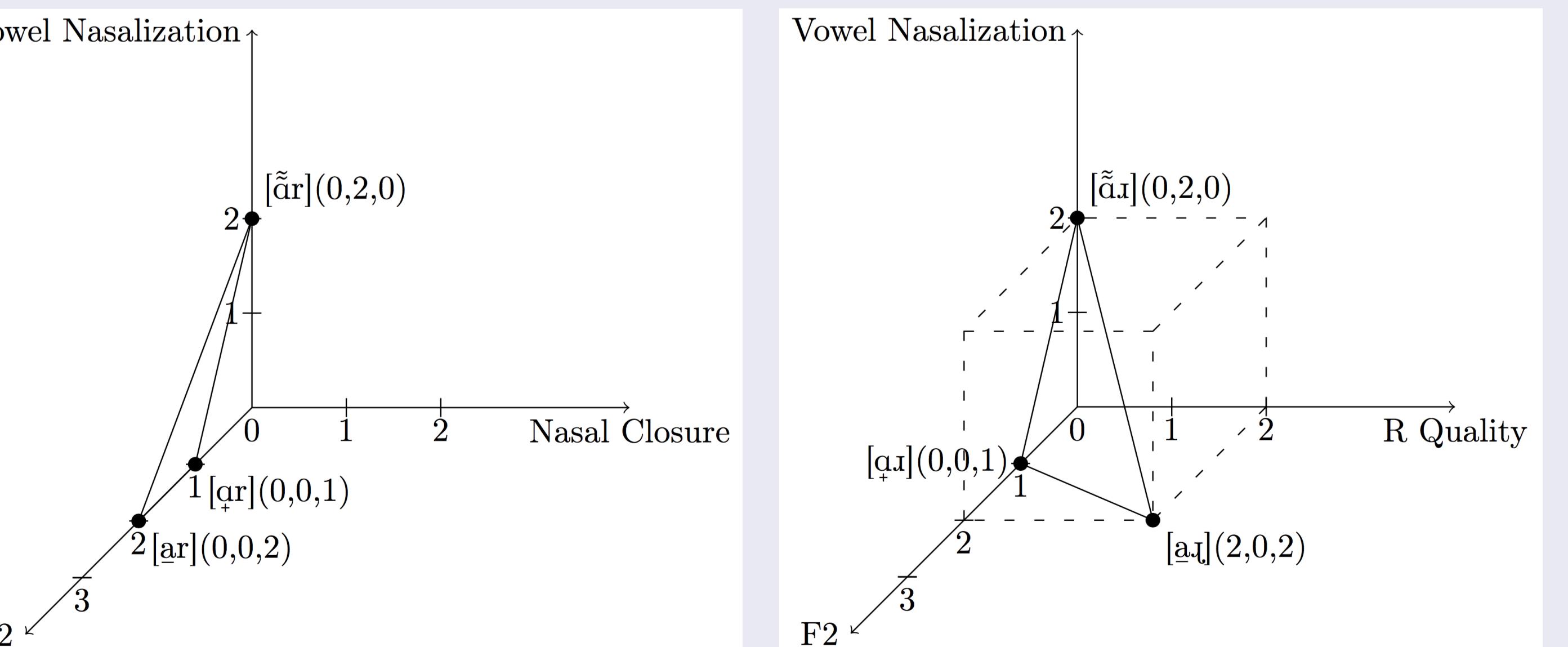
- I argue that the surface variation of the two allophonic /-r/’s is the result of contrast preservation.
- In the suffixed forms, /an/ and /aŋ/ lose their nasal stops.
- With no trigger, the difference in degree of nasalization between [ā] and [āŋ] is hard to perceive, so the weaker [ā] loses its nasalization.
- The /-r/ coda pushes the front [a] and central [ɑ̄] slightly backwards.
- The two rhymes, originally [ān] and [ɑ̄] in the stem form, contrasted in the presence/absence of a nasal closure, nasalization, as well as F2 values.
- But now that they have lost all possible venues of contrast, they look to the suffixed coda /-r/ for contrast preservation.
- /an/ selects for a retroflex, tongue-tip [-ɻ], preserving the contour of formant transition of the stem form.
- /a/ selects for the tongue-body [-ɹ], to maximize its contrast with /an+r/.

Visualization of Vowel Space: Features as Dimensions

- The dimensions:
 - Nasal Closure
 - Open syllable = 0, no closure; [ŋ] coda = 1, incomplete closure; [n] coda = 2, complete closure.
 - Vowel Nasalization
 - Oral vowel V = 0; weakly nasalized vowel Ā = 1; strongly nasalized vowel Ā̄ = 2.
 - F2: higher number corresponds to higher F2 value.
 - R Quality
 - Default [-ɹ] = 0, tongue-body gesture; retroflex [-ɻ] = 2; tongue-tip gesture.
- Stem forms in the vowel space:



Suffixed forms in the vowel space:



MinDist Analysis

- Euclidean distance between each pair of rhymes in the vowel space:

	Stem	Suffixed, 2D	Suffixed, with R
/an+r/, /a+r/	$d([\tilde{a}n], [\tilde{a}]) = \sqrt{6}$	$d([aɹ], [āɹ]) = 1$	$d([aɹ], [āɹ]) = \sqrt{5}$
/a+r/, /ān+r/	$d([\tilde{a}], [\tilde{ā}n]) = 3$	$d([aɹ], [\tilde{ā}n]) = \sqrt{3}$	$d([aɹ], [\tilde{ā}n]) = \sqrt{5}$
/ān+r/, /āŋ+r/	$d([\tilde{ā}n], [\tilde{ā}ŋ]) = \sqrt{11}$	$d([\tilde{ā}n], [āɹ]) = 2\sqrt{2}$	$d([\tilde{ā}n], [āɹ]) = 2\sqrt{3}$

$$\text{MinimalDistance} = \text{RhymeDistance} = \sqrt{5}$$

- MaximizeContrast-OO: Maximize the contrast from another output

Constraints: Nasal Closure & Vowel Nasalization Dimension

- RealizeAffix » *ComplexCoda » Max (Zhang 2000)
- Max[+Nasal]_g » *V_{nas} » Max[+Nasal]_n (Zhang 2000)

Constraints: F2 Dimension

- *F2≥3/_R » *F2≥2/_R
 - Gradient constraints that punish front vowels before an /-r/ coda: coarticulatory effect
- MinDist=F2:1
 - Punishes complete neutralization of vowel backness

[a ₃]-[a ₂]-[a ₀]	MINDIST=F2:1	MAXCONT-OO	*F2≥3/_R	MINDIST=F2:2	*F2≥2/_R	ID[F2]-OO
a. [a ₃]-[a ₂]-[a ₀]			*	*	*	
b. [a ₂]-[a ₁]-[a ₀]				**	*	**
c. [a ₁]-[a ₀]-[a ₀]	**!	*		*		***

Constraints: R Quality Dimension

- Ident[Transition]-OO
 - The formant transition from the vowel to the coda in the suffixed form should be similar to the one in the stem form. A retroflex, tongue-tip [-ɻ] should correspond to an alveolar [n] in the stem form, and a tongue-body [-ɹ] to a velar [ŋ].

[ān]-[q̄]-[āŋ]	MINDIST=RD:√5	MAXCONT-OO	IDENT[TRANS]-OO	MINDIST=RD:3	*_L
a. [aɹ]-[q̄]-[āɹ]	**!		*	*	
b. [aɹ]-[q̄]-[āɹ̄]				*	*
c. [aɹ]-[q̄]-[ā̄ɹ̄]	**!		*	**	
d. [aɹ]-[q̄]-[āɹ̄]			**!	*	**
e. [aɹ]-[q̄]-[ā̄ɹ̄]	**!	*	*	*	***

Conclusion

- In Rhyme Harmony, the contrast between the 3 forms: /an/, /a/, and /ān/ is enhanced by allophonic variation of vowel F2 and nasalization.
- After r-suffixation, such distinctions are lost, but contrast is preserved via another dimension: the quality of /-r/.
- Contrasts are maximized from one output to another, ensuring enough distance between any two rhymes.

Selected References

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