

# Contrast Preservation in Mandarin R-Suffixation

Boer Fu

boerfu@mit.edu

Massachusetts Institute of Technology

## 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	[k <sup>h</sup> an]	'threshold'
(b)	Central [q]	In open syllable	[pq]	'handle'
(c)	Back [ɑ]	Before velar nasal	[t <sup>h</sup> ɑŋ]	'soup'

## R-suffixation, or Erhua

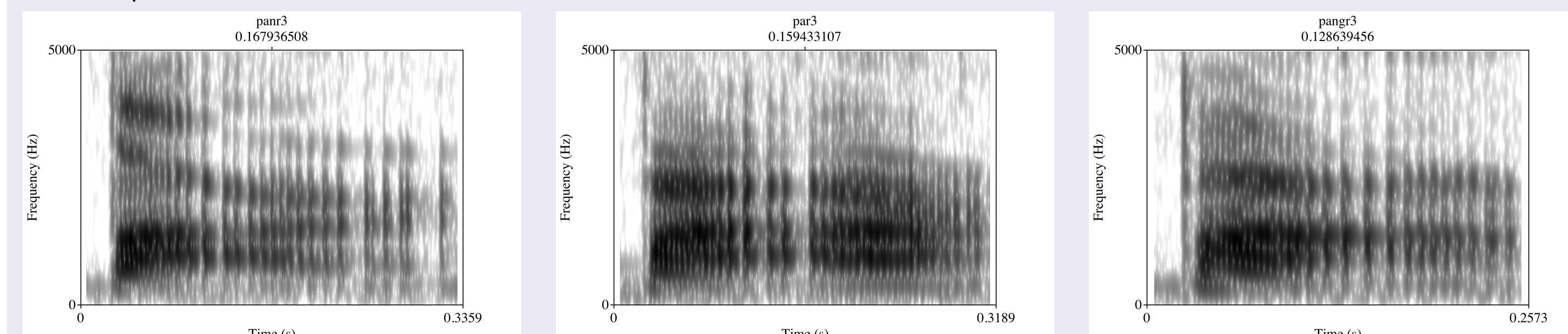
- A diminutive suffix /-r/ can be added to noun stems in many northern dialects of Mandarin.

(2)	STEM	ENGLISH	DIM	ENGLISH	NASAL STOP	Ṽ	Vowel
(a)	[k <sup>h</sup> ān]	'threshold'	[k <sup>h</sup> ar]	'threshold.DIM'	Dropped	Lost	Backed
(b)	[pq]	'handle'	[pqr]	'handle.DIM'	-	-	Backed
(c)	[t <sup>h</sup> āŋ]	'soup'	[t <sup>h</sup> ār]	'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): [āŋ] vs. [āŋ]
- In the Beijing dialect, the stems [āŋ] and [q] 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 [pq]. How?
- Examining the acoustic data collected from three native female speakers:
- Spectrograms of the forms /pan+r/, /pa+r/, and /paŋ+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 /aŋ+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 /aŋ+r/ ( $t = 1.455$ ,  $t = 1.885$ )

- Two /-r/ allophones:

- The regular [-ɹ]: /a+r/ → [qɹ] and /aŋ+r/ → [āɹ]
- The retroflex [-ɻ]: /an+r/ → [aɻ]

- 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.

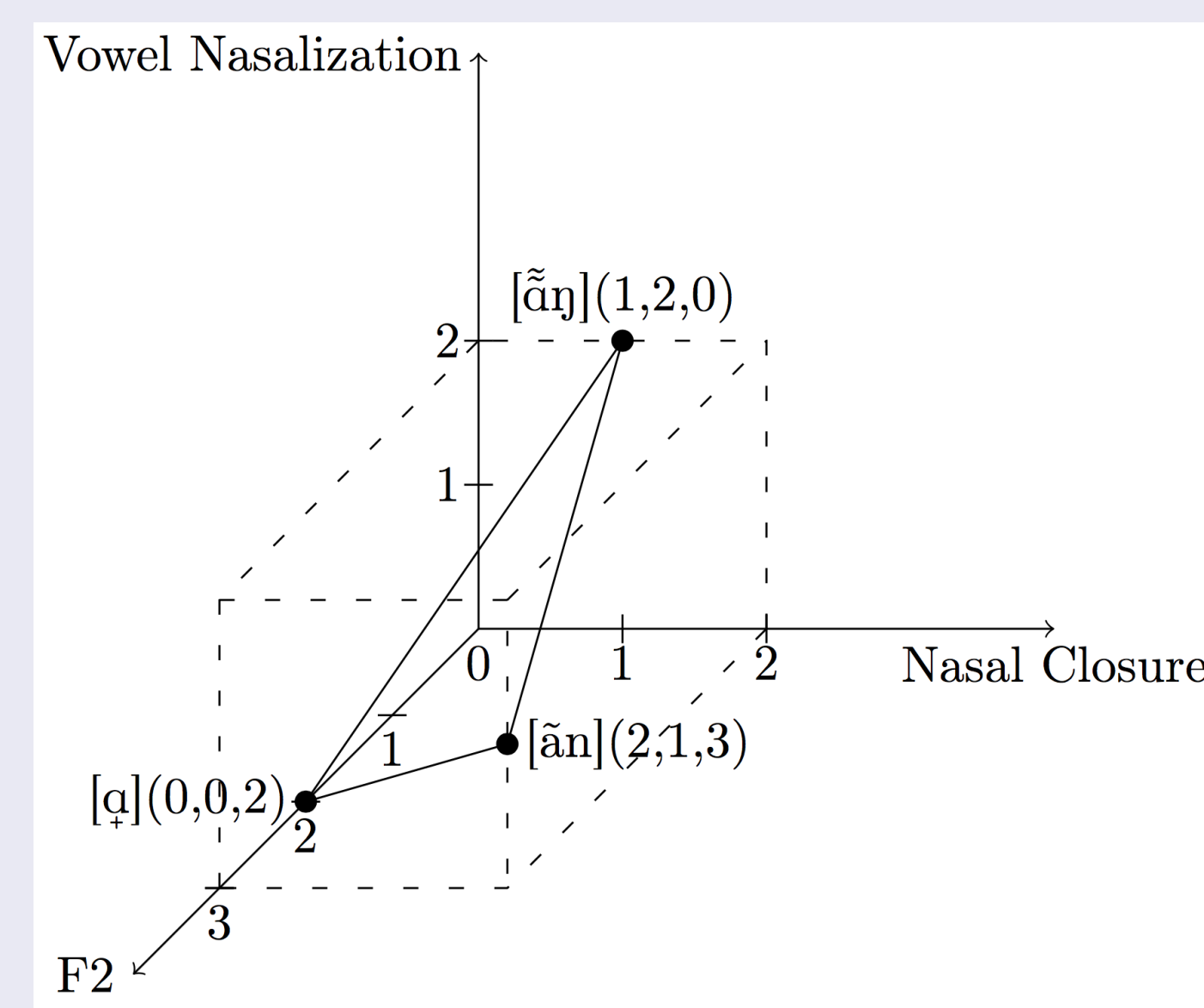
- It is possible that they correspond to the [-ɹ] and [-ɻ] here, respectively.

## Contrast Preservation

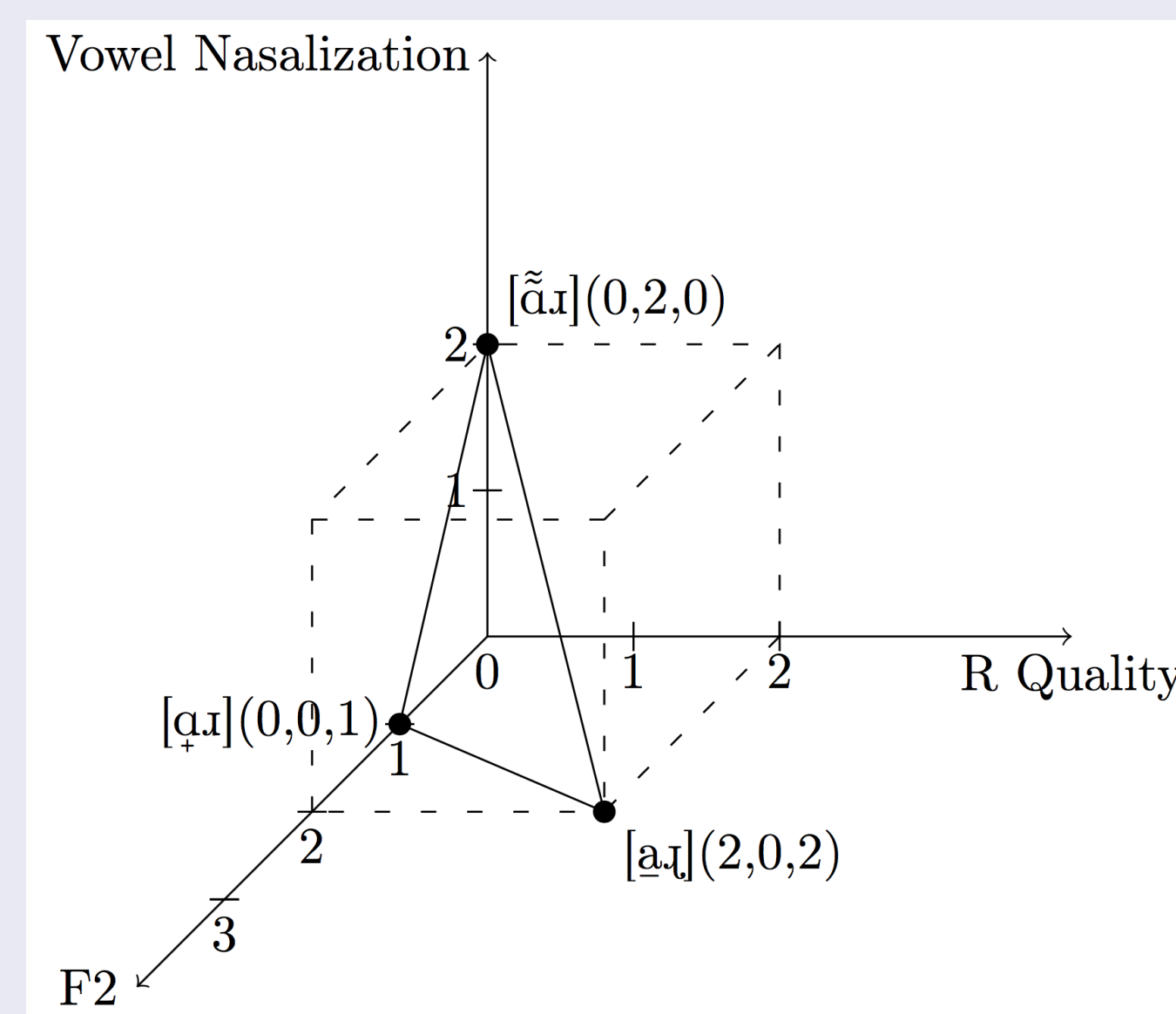
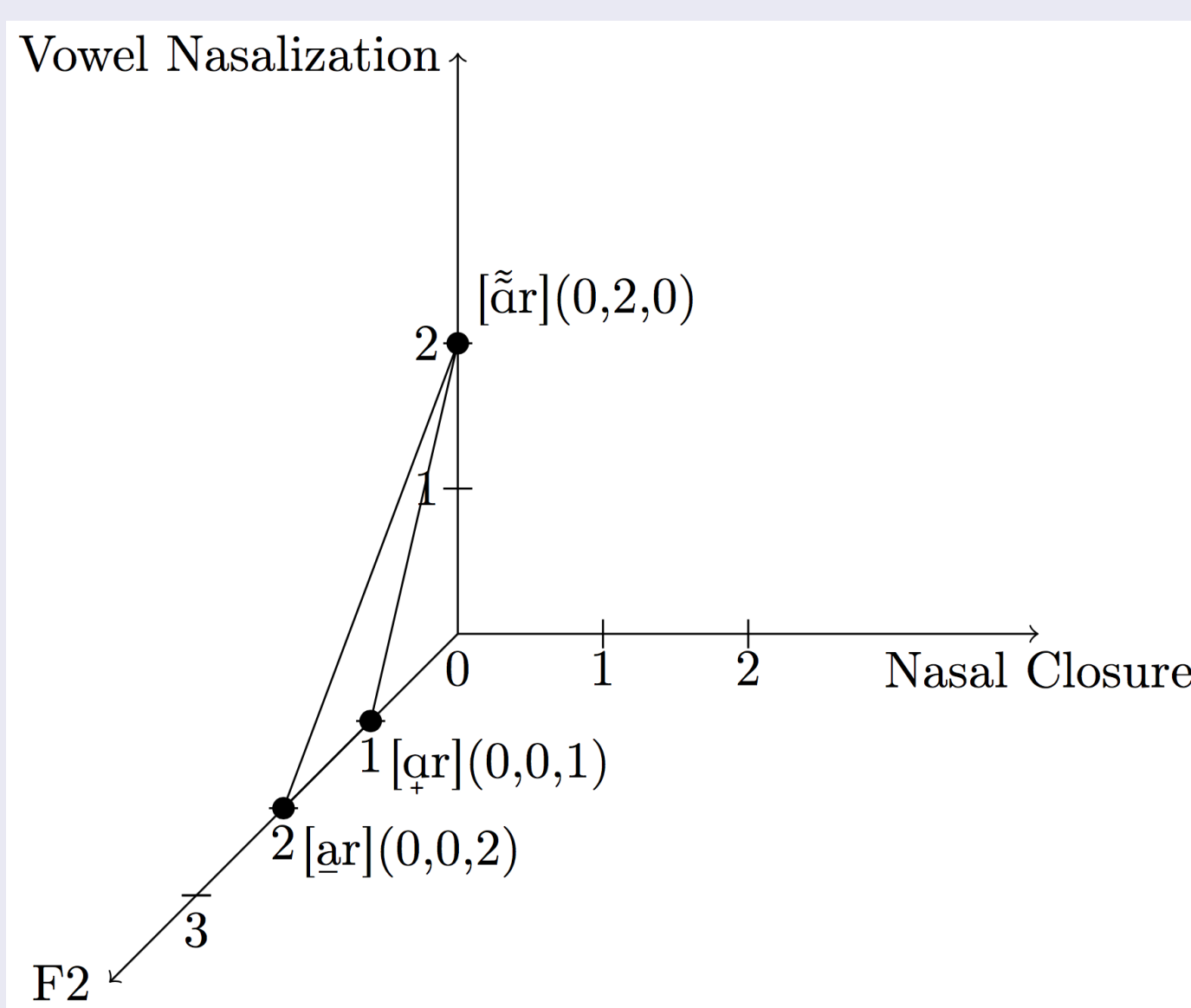
- I argue that the surface variation of the two allophonic /-r/'s is the result of contrast preservation.
- In the suffixed forms, /an/ and /aŋ/ lose their nasal stops.
- With no trigger, the difference in degree of nasalization between [ā] and [ā̃] is hard to perceive, so the weaker [ā] loses its nasalization.
- The /-r/ coda pushes the front [a] and central [q] slightly backwards.
- The two rhymes, originally [āŋ] and [q] 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; [ŋ] coda = 2, complete closure.
  - Vowel Nasalization
    - Oral vowel V = 0; weakly nasalized vowel Ṽ = 1; strongly nasalized vowel Ṽ = 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/	$d([\ān], [q]) = \sqrt{6}$	$d([\ār], [qr]) = 1$	$d([\āɹ], [qɹ]) = \sqrt{5}$
/a+r/, /aŋ+r/	$d([q], [\āŋ]) = 3$	$d([qr], [\ār]) = \sqrt{3}$	$d([qɹ], [\āɹ]) = \sqrt{5}$
/aŋ+r/, /an+r/	$d([\āŋ], [\ān]) = \sqrt{11}$	$d([\ār], [\ār]) = 2\sqrt{2}$	$d([\āɹ], [\āɹ]) = 2\sqrt{3}$

- MinimalDistance=RhymeDistance: $\sqrt{5}$
- MaximizeContrast-OO: Maximize the contrast from another output

## Constraints: Nasal Closure & Vowel Nasalization Dimension

- RealizeAffix » \*ComplexCoda » Max (Zhang 2000)
- Max[+Nasal]<sub>J</sub> » \*V<sub>nas</sub> » Max[+Nasal]<sub>n</sub> (Zhang 2000)

## Constraints: F2 Dimension

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

[a <sub>3</sub> ]-[a <sub>2</sub> ]-[a <sub>0</sub> ]	MINDIST=F2:1	MAXCONT-OO	*F2 $\geq$ 3/_R	MINDIST=F2:2	*F2 $\geq$ 2/_R	ID[F2]-OO
a. [a <sub>3</sub> ]-[a <sub>2</sub> ]-[a <sub>0</sub> ]			*!	*	*	
b. [a <sub>2</sub> ]-[a <sub>1</sub> ]-[a <sub>0</sub> ]				**	*	**
c. [a <sub>1</sub> ]-[a <sub>1</sub> ]-[a <sub>0</sub> ]	*!	*		*		***

## 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 [ŋ] in the stem form, and a tongue-body [ɹ] to a velar [ŋ].

[ān]-[q]-[āŋ]	MINDIST=RD: $\sqrt{5}$	MAXCONT-OO	IDENT[TRANS]-OO	MINDIST=RD:3	*ɻ
a. [aɻ]-[qɻ]-[āɹ]	*!		*	*	
b. [aɻ]-[qɻ]-[āɹ]				*	*
c. [aɻ]-[qɻ]-[āɹ]	*!			*	**
d. [aɻ]-[qɻ]-[āɹ]			*!	*	**
e. [aɻ]-[qɻ]-[āɹ]	*!		*	*	***

## Conclusion

- In Rhyme Harmony, the contrast between the 3 forms: /an/, /a/, and /aŋ/ 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

Duanmu, San. 2007. *The Phonology of Standard Chinese*. Oxford: Oxford University Press. Fleming, Edward. 1995. *Auditory representations in phonology*. PhD dissertation, University of California, Los Angeles. Jiang, Song, Yueh-chin Chang, and Feng-fan Hsieh. 2019. An EMA study of er-suffixation in northeastern Mandarin monophthongs. To appear in *Proceedings of ICPhS 2019*. Zee, Eric, and Wai-Sum Lee. 2001. An acoustical analysis of the vowels in Beijing Mandarin. Seventh European Conference on Speech Communication and Technology. Zhang, Jie. 2000. Non-contrastive features and categorical patterning in Chinese diminutive suffixation: Max[F] or Ident[F]? *Phonology* 17:427-478. Cambridge University Press.

## Acknowledgements

Many thanks to Adam Albright, Edward Fleming, Michael Kenstowicz, Donca Steriade, and MIT Phonology Circle for guidance and feedback.