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The variation of vowel hiatus resolution in Korean

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Outline

0. Goal:

   - To capture the gradual intuition about variable vowel hiatus resolutions in Korean
   - To formalize the variable patterns as a grammar of an individual speaker

1. Types of vowel hiatus resolutions in Korean
2. Previous studies
3. Experiment: Well-formedness test
4. Result
5. Analysis: Stochastic Optimality theory

1. Hiatus resolutions in Korean

- Hiatus:

  Stem-final vowel + Suffix-initial vowel /ʌ, a/

  e.g. c**u**}$_{stem}$ + **ʌ** ‘give’

- Usually, different resolutions are adopted depending on the stem-final vowel quality.

2. The stem-final vowel /i, o, u/

- Glide formation /i, o, u/ → [y, w] /_ + V

✓ Obligatory if no onset

e.g. o + a → wa (*oa) 'come'

✓ Optional if yes onset

e.g. p^hi + ʌ → p^h**y**ʌ ~ p^hiʌ 'bloom'

e.g. nanu + ʌ → nan**w**ʌ ~ nanuʌ 'divide'

2. The stem-final vowel /i, o, u/

- Glide Insertion if yes onset
  - ✓ Optional

  Ø → y /i_+ ʌ   e.g. p^hi + ʌ → p^hi**y**ʌ ~ p^hiʌ

  Ø → w/{o, u}_ + ʌ   e.g. po + a → po**w**a ~ poa

- Hiatus retention if yes onset; No change
  - ✓ Optional

  e.g. p^hi + ʌ → p^h**iʌ** ~ p^hiyʌ ~ p^hyʌ

  e.g. po + a → p**oa** ~ powa ~ pwa

3. The stem-final vowel /e/

- /ʌ/-deletion
  - ✓ Optional

  /ʌ/ → Ø / e + _ e.g. k'e + ʌ → k'**<u>e</u>** 'break'

- /y/- insertion
  - ✓ Optional

  Ø → y / e_+ ʌ e.g. k'e + ʌ → k'e**<u>y</u>**ʌ

- Hiatus retention
  - ✓ Optional e.g. k'e + ʌ → k'eʌ

4. The stem-final vowel /ɨ/

- /ɨ/-deletion
  - ✓ Obligatory

/ɨ/ → Ø e.g. k'ɨ + ʌ → k'<u>ʌ</u> 'extinguish'

Previous studies

1. Glide Formation

- Glide formation is generally regarded as "a kind of shortening process"

- Syllable count effect

  Glide formation is applied more often to polysyllabic than monosyllabic stems.

- Vowel quality effect

  The rate of Glide formation differs depending on the quality of the stem-final vowel

- Different studies provide different descriptions on syllable count effect

i. 기세관 1984, 엄태수 1996

	y glide formation		w glide formation
mono-σ	p^hi + ʌ → p^h**y**ʌ ‘bloom’	<	cu + ʌ → c**w**ʌ ‘give’
poly-σ	tani + ʌ → tan**y**ʌ ‘commute’	>	nanu + ʌ → nan**w**ʌ ‘divide’

ii. 고광모 1991

	y glide formation		w glide formation
mono-σ	p^hi + ʌ → p^h**y**ʌ ‘bloom’	<	cu + ʌ → c**w**ʌ ‘give’

iii. 송철의 1995

	y glide formation		w glide formation
mono-σ	p^hi + ʌ → p^h**y**ʌ ‘bloom’	=	cu + ʌ → c**w**ʌ ‘give’
poly-σ	tani + ʌ → tan**y**ʌ ‘commute’	>	nanu + ʌ → nan**w**ʌ ‘divide’

2. Glide Insertion

- Previous studies differ in the descriptions of the **trigger** of glide insertion.

e.g. pʰiʌ → pʰi**y**ʌ

poa → po**w**a? tuʌ → tu**w**ʌ? t'eʌ → t'e**y**ʌ?

Stem-final vowel	Previous studies
i	정연찬 1997, 유필재 2001
i, o	김현 1999
i, u	강옥미 2003
i, o, u	도수희 1983, 김정태 1999, Kim 2000
i, e, o, u	황규직·신남철 1979, 송철의 1995, 엄태수 1996, 강옥미 2003, 김경아 2003, 최명옥 2004, 이진호 2005, Kim 2000, 임석규 2011

Cf. GI with monosyllabic stem /i/ is preferred over polysyllabic /i/ (엄태수 1996)

pʰiʌ → pʰi**y**ʌ

tani + ʌ → tani**y**ʌ (?)

3. Vowel Coalescence

- Example
  cu+ʌ → co 'give'
  tu+ʌ → to 'put'

- Restrictions
  - ✓ monosyllabic stem-final vowel /u/ (Kim 2000)
  - ✓ lexical exception (Sohn 1987, Lee 2001)

4. Vowel Deletion

- /u/-deletion

  kak'u+ʌ → kak'ʌ 'cultivate'

  nanu+ʌ → nanʌ 'divide'

  ✓ Typically, it is applied to disyllabic stems (Kim 2000)

  cf. Forms with u-deletion are unacceptable (유필재 2001)

- /ʌ/-deletion,

  k'e + ʌ → k'e 'break'

  ✓ No previous studies report how often this deletion may occur.

5. Problems

- No quantitative data
  - ✓ The data of the previous research are mostly based on the intuition of single speaker, i.e. the author.
  - ✓ No previous study reports frequencies of the processes involved in the hiatus resolutions.
  - ✓ There is some disagreement on the previous description of phonological conditions of the processes.
- Korean speakers' intuition regarding the grammaticality of each vowel hiatus resolution has not been captured.
- Few formal analyses of variations have been proposed.

Experiment

1. Task: Well-formedness test

- Participants were asked to judge how natural the stimulus is.

- Well-formedness scale

1 ---- 2 ---- 3 ---- 4 ---- 5	
impossible	very natural

2. Stimuli

- Tokens are selected, considering vowels and syllable count.
  -Vowels: i, o, u, e
  -Syllable count: monosyllable(1), disyllable(2)
- Processes are applied on tokens
  - GF, GI, HR, o, u-Del., ʌ-Del., u-Coal.
- The number of words in each condition

Token / Process	I-1	I-2	U-1	U-2	O-1	E-1	E-2
GF	8	10	5	10	5		
HR	8	10	5	10	5	2	2
GI	8	10	5	10	5	2	2
o, u-Del.			5	10	5		
ʌ-Del.						2	2
u-Coal.			5	3			

3. Stimuli & Subject

- Auditory stimuli were presented with the declarative verb ending **-ʌ**

- The subjects were to assume that stimuli were spoken in casual style.

e.g. katu- ‘lock up’

.
. Retention tweciril katuʌ ‘lock up pigs’
. Glide formation tweciril katwʌ

- Subjects : 40 Seoul Korean speakers (age: 20-30)

Result

1. Result: Well-formedness ratings

- I analyzed the mean ratings with the following as independent variables...

  i. Process   ii. Vowel quality   iii. Syllable count

- Statistics

  - ANOVA(linear regression model)

  - Post-hoc test: Scheffe test,

  - Model comparison

2. Processes of stem-final vowel /i, o, u/

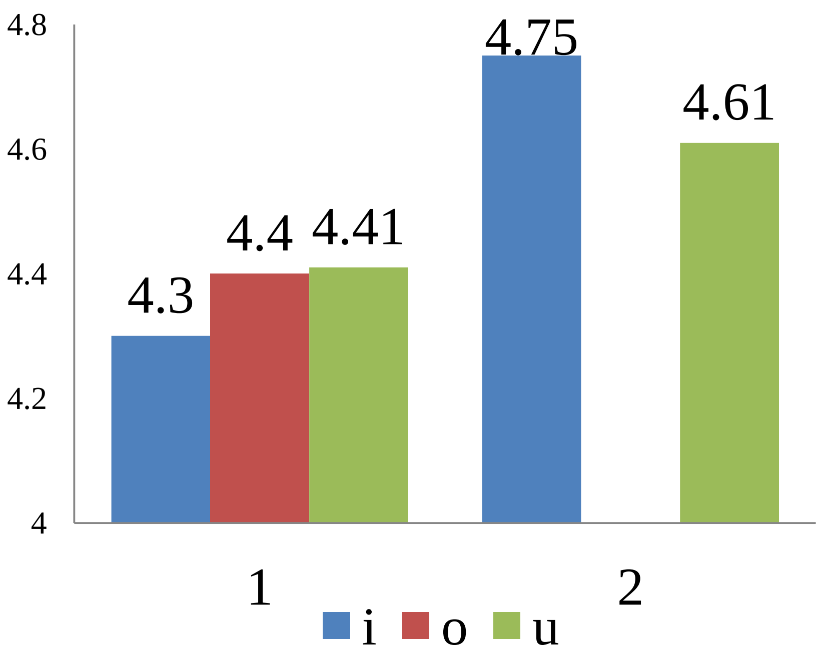
- An order of well-formedness rating for each process

  Glide Formation (4.68) > Hiatus Retention (3.51) > Glide Insertion(3.25)

- The well-formedness of each process is affected by Vowel quality and Syllable count (factor: VS)

- ANOVA aov(well-formedness ~ VS)
  - ✓ Glide formation F-value= 52.78 , $p < 0.001$
  - ✓ Hiatus retention F-value= 32.67 , $p < 0.001$
  - ✓ Glide insertion F-value= 50.42 , $p < 0.001$

3. Glide Formation (1)



- Scheffe test:

Means with the same letter are not significantly different

Groups	Treatments	Means	
a	**I-2**	4.752	?
ab	**U-2**	4.61	?
bc	**U-1**	4.415	
bc	**O-1**	4.406	
c	**I-1**	4.371	?

- The well-formedness of glide formation is higher in disyllabic stems than in monosyllabic stems.
- It seems that /i/ is more affected than /u/ by syllable count.
- However, the syllable count and vowel quality factors aren't clearly confirmed in Scheffe test.

3. Glide Formation (2)

- Linear regression on well-formedness of /i, u/
  - ✓ linear model : lm(rating ~ syllable)
  - ✓ Syllable count factor is significant ($p < 0.001$)
- Vowel quality factor doesn't improve the linear model.
  - ✓ Model comparison
    - Linear Model 1: rating ~ syllable
    - Linear Model 2: rating ~ syllable + vowel $p > 0.05$
- The result of glide formation itself doesn't correspond the previous descriptions which report the vowel quality effect.

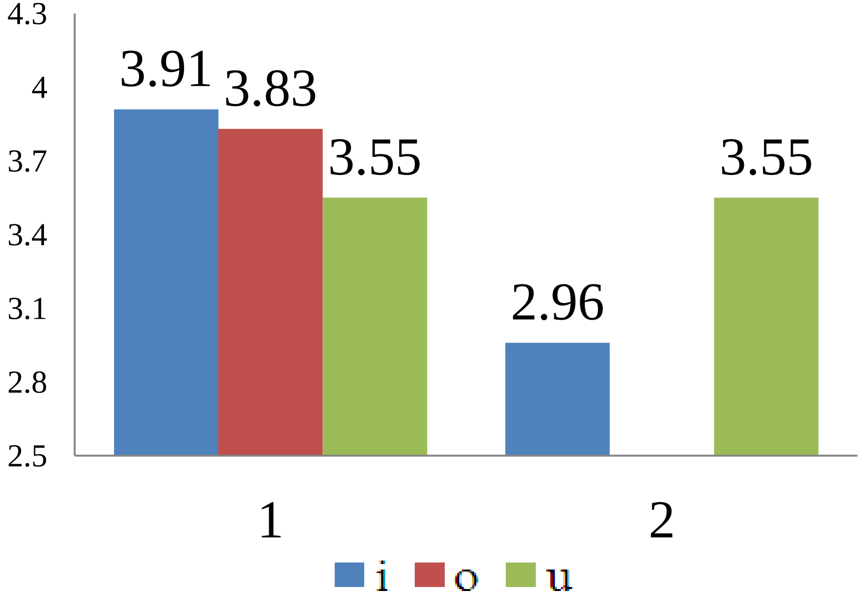
cf. slide 9

3. Glide Formation (3)

- Lexical exceptions with respect to the restriction of glide formation

	Mean	
ki-ʌ → kyʌ	2.575	‘crawl’
c’o-a → c’wa	2.575	‘peck’
i-ʌ → yʌ	2.475	‘place sth on the head’

4. Glide Insertion

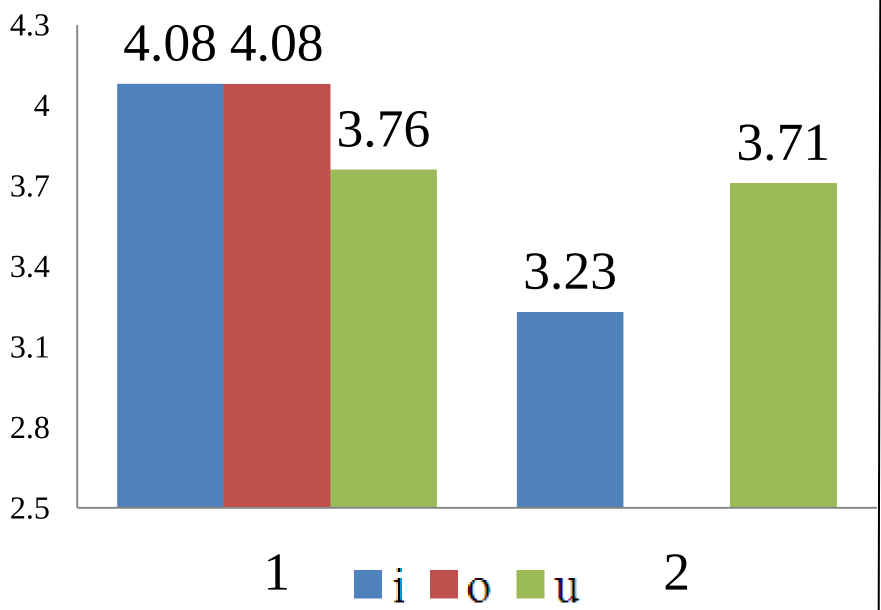


- Scheffe test

Groups	Treatments	Means
a	**I-1**	3.912
a	**O-1**	3.835
b	**U-1**	3.555
b	**U-2**	3.55
c	**I-2**	2.96

- In monosyllabic-stems, ‘i, o’ are preferred over ‘u’.
- In disyllabic-stems, ‘u’ is preferred over ‘i’.
- Stem-final ‘i’ is more affected by the syllable count effect than ‘u’ .

5. Hiatus Retention



- Scheffe test

Groups	Treatments	Means
a	**O-1**	4.085
a	**I-1**	4.083
b	**U-1**	3.769
b	**U-2**	3.718
c	**I-2**	3.236

- In monosyllabic-stems, ‘i, o’ are more likely to tolerate hiatus.
- In disyllabic-stems, ‘u’ is more likely to tolerate hiatus.
- Stem-final ‘i’ is more influenced by the syllable count effect than ‘u’.

6. Correlations with Hiatus Retention

- The negative correlation with Glide Formation

. The coefficient of correlation: -0.416 ($p < 0.1$)

Hiatus Retention : I-1, O-1 > U > I-2

Glide Formation : I-1, O-1, U- 1 < U-2, I-2

. Unlike the prediction of previous studies, the correlation isn't fully significant.

- The positive correlation with Glide Insertion.

. The coefficient of correlation: 0.864 ($p < 0.0001$)

Hiatus Retention : I-1, O-1 > U > I-2

Glide Insertion : I-1, O-1 > U > I-2

. The correlation wasn't mentioned in previous studies.

7. Other processes in Stem-final vowel /o, u/

- /o, u/ deletion
  - ✓ U-2(3.44) > U-1(2.9) > O-1(2.45)
  - ✓ The deletion of disyllabic stem-final vowel /u/ is not totally unacceptable.

    e.g. nanu+ʌ → nanʌ 'divide'

- /u/-coalescence forms, 'to, co', are relatively preferred over other words with stem-final /u/

		Mean	
e.g.	cu-ʌ → co	3.8	'give'
	tu-ʌ → to	3.25	'put'

8. Processes of stem-final vowel /e/

	E-1	E-2
HR	3.7	3.48
GI	3.0	2.9
ʌ-Del	4.47	4.47

- ✓ ʌ deletion > Hiatus Retention > Glide Insertion
- ✓ In each process, there is no syllable count effect

9. Summary

Process \ Token	I-1	I-2	U-1	U-2	O-1	E-1	E-2
Glide Formation*	4.3	4.75	4.41	4.61	4.4		
Hiatus Retention	4.08	3.23	3.76	3.71	4.08	3.7	3.48
Glide Insertion	3.91	2.96	3.55	3.55	3.83	3.03	2.9
o, u-Deletion			2.95	3.44	2.45		
ʌ-Deletion						4.47	4.47
u-Coalescence**			2.62	2.4			

✓ Exception

* ki-ʌ → kyʌ 2.575 i-ʌ → yʌ 2.475 c'o-a → c'wa 2.575

** tu-ʌ → to 3.25 cu-ʌ → co 3.8

Analysis :
Stochastic Optimality theory

1. General constraints

i. Constraints prohibiting **hiatus retention**

***VV**: The sequence Vowel-Vowel is not allowed

ii. Constraints prohibiting **glide formation**

***CG**: The sequence Consonant-Glide is not allowed in onset

IDENT(syllabic): Corresponding segments have identical values for feature [syllabic]

iii. Constraints prohibiting **glide insertion**

DEP(ROOT): Output segments must have input correspondents

iv. Constraints prohibiting **deletion**

MAX-[V]: Input vowels must have output correspondents

Casali 1996, Kim 2000

2. Constraints

- Constraints are subdivided for different phonological factors.
- In case of *VV, DEP(ROOT),
  - ✓ Constraints of each vowel are adopted.
  - ✓ Constraints of /i/ are conjoined with syllable count.

i. *VV: *iV-1, *iV-2, *oV, *uV, *eV, *ɨV

ii. DEP(ROOT): DEP(ROOT)-1-i, DEP(ROOT)-2-i
DEP(ROOT)-o, DEP(ROOT)-u, DEP(ROOT)-e

- *CG is specified for monosyllabic stems and disyllabic stems.

*CG: *CG-1, *CG-2

3. Vowel faithfulness constraints

- The target of the process is determined by the ranking between vowel faithfulness constraints.

- MAX constraints for each vowel segment are adopted.

- MAX-[**ɨ**], MAX-[**u**], MAX-[**o**], MAX-[**ʌ**]

  MAX-[**i**], MAX-[**e**], MAX-[**a**]

4. Lexically specified constraints (Pater 2000)

i. Constraints prohibiting **/u/-coalescence**

UNIFORMITY-L1:

No element of the output in words of L1 has multiple correspondents in the input. (L1: words with stem-final /u/ except 'cu-, tu-')

UNIFORMITY-L2:

No element of the output in words of L2 has multiple correspondents in the input . (L2: 'cu-, tu-')

ii. Constraints prohibiting **Glide formation**

ID(syllabic)-L3:

Correspondent segments in words of L3 have identical values for feature [syllabic]. (L3: 'ki-, i-, c'o')

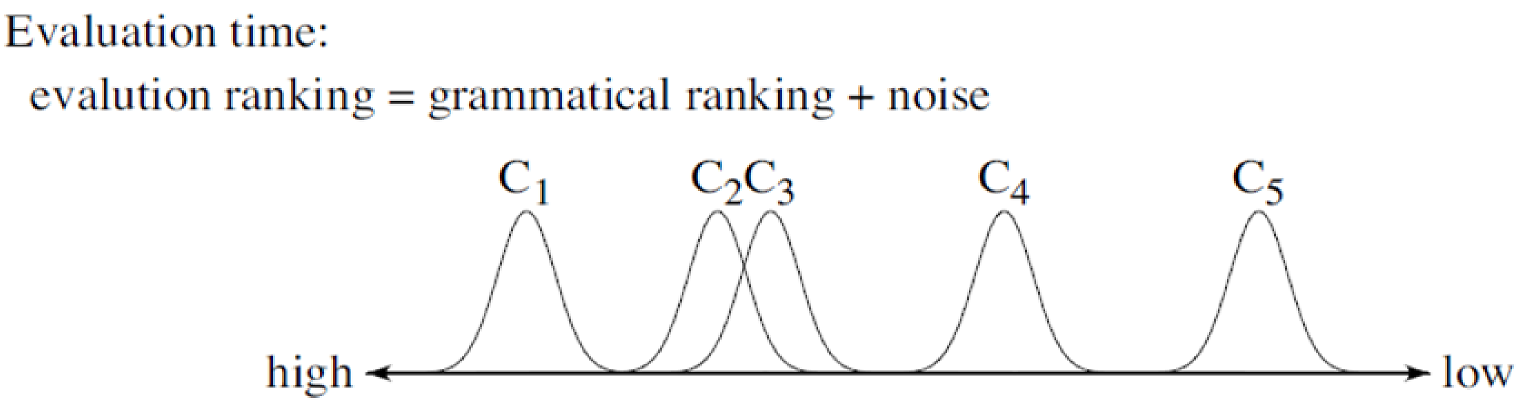
5. Variable ranking

	MAX [V]	DEP (ROOT)	*VV	*CG	ID(syllabic)	Uniformity
Deletion	*					
Insertion		*				
Retention			*			
Formation				(*)	*	
Coalescence						*

- What is the mechanism of variable ranking?
- How can the grammar predict quantitative aspect?

6. Stochastic Optimality Theory

- Probabilistic ranking model
- Ranking values are numerically assigned along a continuous scale
- In evaluation, constraints are simultaneously associated with normal distribution of noise.
- When the distributions overlap, the ranking can be reversed.



(Boersma 2003:1, 2d)

Boersma and Hayes 2001, Hayes and Londe 2006

7. Learning the stochastic grammar

- Gradual Learning Algorithm (Boersma and Hayes 2001)
  - The algorithm assign the ranking value of Stochastic OT

- OT soft 2.3.1 (Hayes, Bruce, Bruce Tesar, and Kie Zuraw 2003)

. Number of times to go through forms	100000
. Initial plasticity	1
. Final plasticity	0.001
. Number of times to test grammar	100000
. Noise	2.0
. Initial ranking value	100

8. Input Data

			MAX-[ʌ]	MAX-2-[u]	*uV	DEP(ROOT)-u	*CG-2	ID(syllabic)
CuV2	CuV2	27.6			1			
	CwV2	67.7					1	1
	CuwV2	23.5				1		
	CV2	21.1		1				
	Cu2	0	1					
uV2	uV2	0			1			
	wV2	100						1
	uwV2	0				1		
	V2	0		1				
	u2	0	1					

- Well-formedness data has the limit on scale, unlike frequency.
- Well-formedness data → Frequency-like data
  - ✓ Transformation (Coetzee and Kawahara, to appear)

predicted frequency = (e^r/e^5) X 100

[e = 2.71, r = well-formedness rating]

9. Patterns learned

I. Patterns in Experiment

i. Monosyllabic/Disyllabic stem-final /i, o, u/ with onset
ii. Stem-final /e/
iii. Exceptions of glide formation: ki-, i-, c'o

II. Included Obligatory patterns

i. Monosyllabic stem-final vowel /o/ without onset
ii. Disyllabic stem-final vowel /i, u/ without onset
iii. Stem-final vowel /ɨ/

10. Ranking value

- Ranking values are assigned to yield probability distribution of candidates.

Constraint	Ranking value	Constraint	Ranking value
MAX-[e]	112.141	MAX-1-[u]	97.997
DEP(ROOT)-E	107.447	MAX-2-[u]	97.591
*eV	106.454	DEP(ROOT)-u	97.384
MAX-[i]	106	*uV	97.205
MAX-[a]	105	DEP(ROOT)-o	96.913
MAX-[ʌ]	104.958	*oV	96.496
*ɨV	103.001	DEP(ROOT)-1-i	96.475
MAX-[o]	99.656	*1-iV	96.331
DEP(ROOT)-2-i	98.742	*CG-1	95.959
*2-iV	98.393	*CG-2	95.817
ID(syllabic)-L3	98.097	MAX-[ɨ]	92.999
		ID(syllabic)	89.828

Average error per candidate: 0.018 percent

11. Ranking value : stem-final /i, o, u/

- The ranking value of ID(syllabic) is low enough for GF to apply obligatorily if there is no onset.
- The raking values of *VV and *CG are close enough to each other, so that GF apply optionally if there is an onset.
- With the sets of *VV and *CG, the set of DEP(ROOT) is also close enough to each other, so that GI may apply optionally if there is an onset.

Constraint	Ranking Value
DEP(ROOT)-2-i	**98.742**
***2-iV**	**98.393**
DEP(ROOT)-u	**97.384**
***uV**	**97.205**
DEP(ROOT)-o	**96.913**
***oa**	**96.496**
DEP(ROOT)-1-i	**96.475**
***1-iV**	**96.331**
***CG-1**	**95.959**
***CG-2**	**95.817**
ID(syllabic)	**89.828**

12. Ranking value: Deletion

- The ranking values of MAX-[ɨ] are low enough for ɨ-deletion to apply obligatorily.
- The raking values of *eV and MAX-[ʌ] are close to each other, so that ʌ-deletion is applied optionally.
- The raking values of *oV and MAX-[o] aren’t close enough for o-deletion to apply frequently.
- The ranking values of *uV, MAX-1-[u], and MAX-2-[u] are close, so that u-deletion is likely acceptable.

Constraint	Ranking Value
MAX-[e]	112.141
DEP(ROOT)-E	107.447
*eV	106.454
MAX-[a]	105
MAX-[ʌ]	104.958
*ɨV	103.001
MAX-[o]	99.656
MAX-1-[u]	97.997
MAX-2-[u]	97.591
*uV	97.205
*oV	96.496
MAX-[ɨ]	92.999

Conclusion

i. Previous studies are short of consistent and quantitative data

ii. I report well-formedness of processes from experiment.

iii. The gradual intuition in context of vowel hiatus is formalized by Stochastic OT.

iv. The grammar can predict the variable patterns with precise probabilistic distributions.

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Thank you

Thank you

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I. Patterns in Experiment

CuʌI	CuʌI	29	CiʌI	CiʌI	39.9	CoaI	CoaI	39.9
	CwʌI	55.5		CjʌI	49.7		CwaI	54.9
	CuwʌI	23.5		CijʌI	33.7		CowaI	31.1
	CʌI	12.9		CʌI	0		CaI	7.8
	CuI	0		CiI	0		CoI	0
Cuʌ2	Cuʌ2	27.6	Ciʌ2	Ciʌ2	17.1	eʌ	eʌ	24.5
	Cwʌ2	67.7		Cjʌ2	77.9		e	58.9
	Cuwʌ2	23.5		Cijʌ2	13		ejʌ	13
	Cʌ2	21.1		Cʌ2	0		ʌ	0
	Cu2	0		Ci2	0			
iʌI	iʌI	39.9	kiʌI	kiʌI	39.9	c'oaI	c'oaI	39.9
	jʌI	8.1		kjʌI	8.9		c'waI	8.9
	ijʌI	33.7		kijʌI	33.7		c'owaI	31.1
	ʌI	0		kʌI	0		c'aI	0
	iI	0		kiI	0		c'oI	0

II. Including Obligatory patterns

oaI	oaI	0	uʌ2	uʌ2	0	iʌ2	iʌ2	0
	waI	100		wʌ2	100		jʌ2	100
	owaI	0		uwʌ2	0		ijʌ2	0
	aI	0		ʌ2	0		ʌ2	0
	oI	0		u2	0		i2	0
ɨʌ	ɨʌ	0						
	ɨ	0						
	ʌ	100						