DECAY OF UNGROUNDED RULES: MIDDLE KOREAN VOWEL HARMONY IN CONTEMPORARY KOREAN

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1 Introduction

Korean vowel harmony refers to the alternation of the initial vowel of verbal suffixes depending on the final vowel of stems. Only vowel-initial suffixes adjacent to stems are affected by the rule. In principle, /a/-initial suffixes occur after /a, o/-final stems, and /ə/-initial ones occur after stems with other final vowels /ə, u, ɨ, i, e, ɛ, y, ø/ as in Table 1.

Table 1. Examples of Korean vowel harmony

Stem		+ Imperative	+ Declarative	+ Reason
m**a**k-	'block'	m**a**k-**a**(la)	m**a**k-**a**jo	m**a**k-**a**sə
p**o**-	'look'	p**o**-**a**(la)	p**o**-**a**jo	p**o**-**a**sə
m**ə**k-	'eat'	m**ə**k-**ə**(la)	m**ə**k-**ə**jo	m**ə**k-**ə**sə
p**u**s-	'pour'	p**u**s-**ə**(la)	p**u**s-**ə**jo	p**u**s-**ə**sə
ɨlph-	'recite'	**ɨ**lph-**ə**(la)	**ɨ**lph-**ə**jo	**ɨ**lph-**ə**sə
m**i**l-	'push'	m**i**l-**ə**(la)	m**i**l-**ə**jo	m**i**l-**ə**sə
tall**ɛ**-	'soothe'	tall**ɛ**-**ə**(la)	tall**ɛ**-**ə**jo	tall**ɛ**-**ə**sə
p**e**-	'cut'	p**e**-**ə**(la)	p**e**-**ə**jo	p**e**-**ə**sə
t^{h}**ø**-	'spatter'	t^{h}**ø**-**ə**(la)	t^{h}**ø**-**ə**jo	t^{h}**ø**-**ə**sə
k'**y**-	'release'	k'**y**-**ə**(la)	k'**y**-**ə**jo	k'**y**-**ə**sə

The rule is a residual of RTR (retracted tongue root) vowel harmony in Middle Korean. Through historical changes of the vowel system of Korean, RTR is not a contrastive feature for vowels anymore and there are no natural classes for the vowel grouping of the rule (/a, o/ vs. other vowels) in Contemporary Korean. Thus, we can expect some sort of decline in consistency of the ungrounded rule.

In *Proceedings of GLOW in Asia XI*, volume 2, edited by Michael Yoshitaka Erlewine.
MIT Working Papers in Linguistics #85. Cambridge, MA: MIT Working Papers in Linguistics.

In fact, the decay of Korean vowel harmony has been reported (Kang, H. 2012, Kang, Y & Ryu 2015), and it has been claimed as unidirectional paradigm leveling. Results of previous studies are summarized as in (1).

(1) a. Existing stems
i. Variations after /a/-final stems (ex) m**a**l-**a** ~ m**a**l-**ə** 'roll'
ii. No variations after /o/-final stems (ex) m**o**l-**a** *m**o**l-**ə** 'drive'
b. Nonce stems
Variations after both /a, o/-final stems

Since /a, o/-final stems allow disharmonic /ə/-initial suffixes in production experiments and corpus studies, researchers argue that suffix-initial vowels are being unified into /ə/ regardless of stem-final vowels. Southern Chungcheong dialects provide further evidence in support of this argument: suffixes are /ə/-initial after all kinds of stem-final vowels (Kwak 1999) as in (2).

(2) m**a**k-**ə**sə 'block-reason', c**o**p-**ə**sə 'narrow-reason', m**ə**k-**ə**sə 'eat-reason'

Prior research, however, focused only on stem-final /a, o/. Since other stem-final vowels are not compared under the same conditions as /a, o/, we cannot rule out the possibility that other stem-final vowels than /a, o/ also will allow disharmonic suffixes in verbal conjugation forms. Indeed, there are dialects indicating only vowels other than /a, o/ allow disharmonic suffixes. In Northern Kyeongsang dialects at the eastern coast, suffixes are unified as being /a/-initial regardless of stem-final vowels (Kwak 1999) as in (3).

(3) m**a**k-**a**sə 'block-reason', p**u**s-**a**sə 'pour-reason', t**i**t-**a**sə 'hear-reason'

From bidirectional paradigm leveling across dialects, it is inferred that every stem-final vowel condition must be compared in order to figure out the direction of decay of Korean vowel harmony. This study explores alternation patterns of suffix-initial vowels after stem-final /a, o, ə, u, ɨ, i/ conditions through a production experiment using both existing and nonce stems. Due to the very small number of monosyllabic existing words having them as final vowels, stem-final /e, ɛ, y, ø/ conditions are not considered in the current study. In contrast to prior work, the current experimental results reported here suggest that in the decay of Korean vowel harmony, bidirectional paradigm leveling across various stem-final vowel conditions can be observed even within individual speakers.

The rest of the paper is organized as follows. The second section presents the hypotheses and predictions. The third section describes the experimental stimuli and procedure, while the fourth presents the experimental results based on the direction of paradigm leveling. The last section draws some conclusions and discusses the limitations.

2 Research Hypotheses and Predictions

The aim of this study is to investigate alternation patterns of suffix-initial vowels across various stem-final conditions through production experiments. Three hypotheses and corresponding predictions on the direction of paradigm leveling based on production patterns of Korean vowel harmony are set out as in (4).

(4) Hypotheses and predictions

a. Unidirectional paradigm leveling across speakers
Every participant allows both harmonic /a/-initial and disharmonic /ə/-initial suffixes after stem-final /a, o/ conditions, but only harmonic /ə/-initial suffixes after stem-final /ə, u, ɨ, i/ conditions.

b. Bidirectional paradigm leveling across speakers
Some participants allow disharmonic suffixes only after stem-final /a, o/ conditions, but other participants allow disharmonic suffixes only after stem-final /ə, u, ɨ, i/ conditions.

c. Bidirectional paradigm leveling within speakers
Disharmonic suffixes are allowed after various stem-final conditions in responses from the same participant.

The first hypothesis is based on the argument presented in prior work. Following this hypothesis, it is predicted that every participant shows the paradigm leveling of suffix-initial vowels to /ə/.

The second hypothesis is based on dialectal data: the unification of suffix-initial vowels to /a/ as in southern Chungcheong vs. to /ə/ as in northern Kyeongsang dialects at the eastern coast. Unidirectional paradigm leveling of suffix-initial vowels could happen in two different directions across speakers as shown in dialectal data.

The third hypothesis is based on the assumption that speakers may attempt to introduce the new generalization of vowel grouping for the vowel harmony rule while maintaining two alternates for suffix-initial vowels. If this is the case, bidirectional inter-paradigm leveling within speakers is predicted, instead of paradigm unification.

3 Production Experiment

3.1 Participants

Seventeen Seoul Korean speakers (eight males and nine females) with a mean age of 26.7 (18~33) participated. Three participants are excluded in the data analysis due to unnatural or non-canonical responses. One participant is excluded in the analysis because the data fitting model used in the current study (GMM, refer to the section 3.4) cannot reflect the data distribution well.

3.2 Materials

Stimuli are 114 items consisting of 38 closed monosyllabic (C)VC(C) stems and three suffixation frames. Table 2 lists both existing and nonce stems for 6 stem-final vowel conditions, /a, o, ə, u, ɨ, i/. The most preferred onset and coda consonants are labial stops which minimize tongue coarticulation. If there is no proper existing stem obeying this condition, coronal stops are selected.

Table 2. Stimuli in the production experiment

Stem-final	Existing stem	Nonce stem
a	*palp-* 'step on', *pat-* 'receive'	*pap-, pap^h-, pam-, p'alp*
o	*p'op-* 'pick', *tot-* 'come up'	*pop-, pop^h-, pom-, p'olp*
ə	*əp-* 'carry on one's back', *əp^h-* 'overturn', *t'əlp-* 'bitter'	*pəp-, pəp^h-, pəm-, p'əlp*
u	*kup-* 'bend', *p'um-* 'spurt', *put^h-* 'stick'	*pup-, pup^h-, pum-, p'ulp*
i	*ip-* 'put on', *tit-* 'step'	*pip-, pip^h-, pim-, p'ilp*
ɨ	*ɨlph-* 'recite', *t'ɨt-* 'pluck'	*pɨp-, pɨp^h-, pɨm-, p'ɨlp*

Three suffixation frames are listed in (5). They are made by using *ha-* 'do' as an irregular verb to avoid any explicit cue for selection of a specific suffix-initial vowel. Non-final suffixation frames in (5b) are serial verb constructions.

(5) a. Sentence-final suffixation frame
~hɛ 'do'

b. Non-final suffixation frames with two different following vowels
~hɛ bat-ta [bat-t'a] '(after) doing, receive-dec'
~hɛ bəs-ta [bət-t'a] '(after) doing, take off-dec'

3.3 Procedure

In each screen, a stem and a suffixation frame are given in written forms as in the left side of (6a). Since in Korean verb or adjective stems cannot stand independently without any suffixes, stems are presented with a declarative suffix *-ta* as in Korean dictionaries. Suffixation frames are given by using conjugation forms of *ha-* 'do'. Participants are asked to produce a natural verbal conjugation form of a given stem based on the given conjugation form of *ha-* 'do' in each screen. The example of questions is "*ha-ta* becomes *hɛ*, then what does *pam-ta* become? Produce the expected form." Participants must replace *-ta* with a suffix-initial vowel /a/ or /ə/ in order to make a verbal conjugation form corresponding to the given suffixation form as in (6b).

(6) a. stimuli: a stem-*ta* + a suffixation frame using *ha-* 'do'
ex) 밤다 + ~해 *pam-ta* + *~hɛ*
밤다 + ~해 받다 *pam-ta* + *~hɛ bat-ta*
밤다 + ~해 벗다 *pam-ta* + *~hɛ bəs-ta*

b. expected responses: the given stem-***a*** or the given stem-***ə***
ex) *pam-**a*** or *pam-**ə***
*pam-**a** bat-ta* or *pam-**ə** bat-ta*
*pam-**a** bəs-ta* or *pam-**ə** bəs-ta*

In the experiment, examples and practices are provided before starting the test. Existing stems *mɛc-* 'bear', *p'ɛs-* 'take away', and *pɛth-* 'spit' are used as an example and two practice stems each with three suffixation frames. Since these stems select /ə/-initial suffixes in principle, the test always starts with two consecutive /a/-final existing and nonce stems in order to avoid

possible bias to /ə/-initial suffixes in responses. Matching suffixes to the two beginning stems are randomly provided.

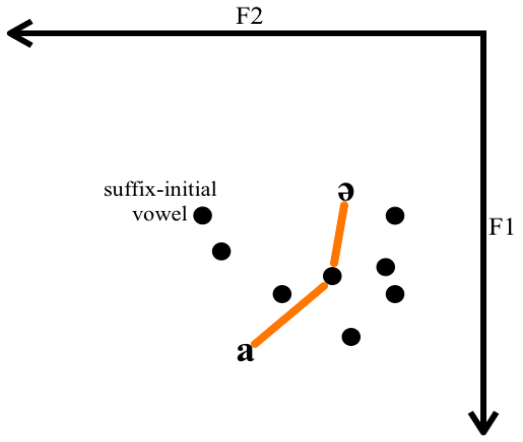
The first test cycle includes 57 stimuli items, and after a short break, the second test cycle includes the remaining 57 stimuli items. In total, 114 stimuli are presented to each participant in a pseudo-randomized order. None of the same stem-final vowels (except for the first two /a/-final ones), coda consonants, and suffixation frames are repeated in a row.

3.4 Analysis

F1 and F2 of reference vowels (stem-final /a/ and /ə/) and suffix-initial vowels are measured separately for each participant. Each vowel in the recorded audio files is labeled in the text grids in Praat. Vowel segmentation took place at the beginning or end of voicing in general. Using the text grids and corresponding audio files, formant values are automatically measured by using a Praat Script. A scale factor of 50% is applied to all of the target formants. Data points which seem to be outliers considering the value of mean + 2.5 standard deviation are manually checked.

Since two alternates for suffix-initial vowels /a/ and /ə/ are very similar to each other, suffix-initial vowels produced by participants may not have been straightforwardly categorizable. Perceptual categorization by the author as a native Korean speaker could have been biased due to the effects of formal education about Korean vowel harmony as one of major grammar rules for Korean. For these reasons, in this paper automatic categorization of suffix-initial vowels is conducted based on relative Euclidean distance to reference vowels. The Euclidean distance measurement is schematized as Figure 1.

Figure 1. Schematized Euclidean distance between reference vowels and a suffix-initial vowel



Euclidean distances are calculated based on F1 and F2 between each suffix-initial vowel and the center (mean) of the reference vowels /a/ and /ə/ produced by the same participant as in (7).

(7) Calculation of the Euclidean distance between

a. suffix vowels and the mean of the reference /a/

$$\sqrt{(suffixV\_F1 - mean(a_{\text{reference}}\_F1))^2 + (suffixV\_F2 - mean(a_{\text{reference}}\_F2))^2}$$

b. suffix vowels and the mean of the reference /ə/

$$\sqrt{(suffixV\_F1 - mean(ə_{\text{reference}}\_F1))^2 + (suffixV\_F2 - mean(ə_{\text{reference}}\_F2))^2}$$

As a measure of the relative similarity to /a/ and /ə/ of suffix-initial vowels, the log of the ratio between the two Euclidean distances is calculated. The distance between a given suffix vowel and the reference /a/ is divided by the distance between suffix vowels and the reference /ə/, and the result of the division is logged as in (8).

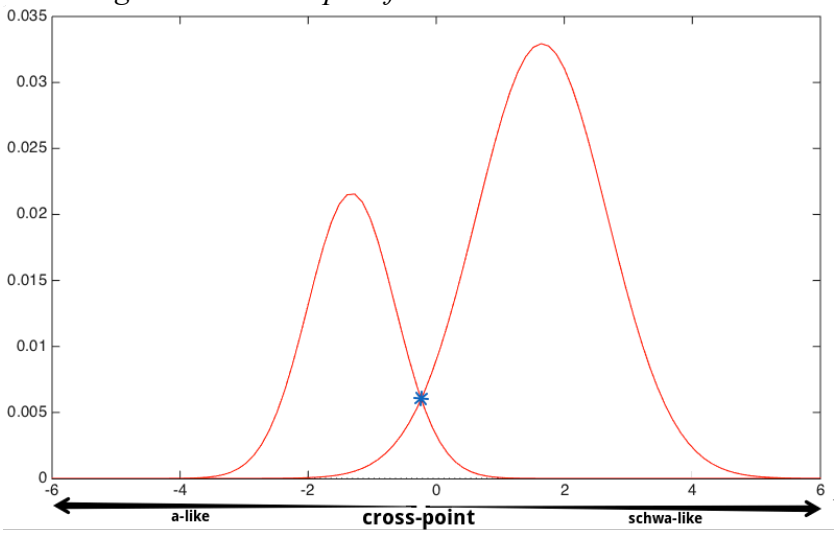
(8) Log ratio between the two Euclidean distances to /a/ vs. /ə/

$$log\left(\frac{Euclidean\ distance\ between\ suffix\ V\ and\ the\ mean\ of\ a_{\text{reference}}}{Euclidean\ distance\ between\ suffix\ V\ and\ the\ mean\ of\ ə_{\text{reference}}}\right)$$

The log ratio measure is classified by using Gaussian Mixture Model (GMM) fitting in Matlab. If the data distribution fits a single Gaussian curve, it means that all of the given data points have the same property. Thus, they will be classified into the same cluster. In such cases, the log ratio of the center of the Gaussian distribution determines the property of the cluster. If the log ratio of the center is negative, suffix-initial vowels included in the cluster are more similar to /a/ than /ə/ (in other terms, they are more /a/-like). Positive log ratio means that suffix-initial vowels in the cluster are /ə/-like.

If the data distributions fit two different Gaussian curves, it is interpreted that there are two types of data points with distinct properties. They will be classified into two clusters. If two Gaussian curves are totally separated, properties of the clusters are decided based on the log ratio of their centers. However, if two curves are overlapped (a mixture of two Gaussian distributions), the cross-point between them is referred. Suffix-initial vowels which are left of the cross-point are classified as being more /a/-like, and ones right of the point are /ə/-like as in Figure 2.

Figure 2. An example of two Gaussian distributions



4 Results

Across participants' responses there are various alternation patterns of suffix-initial vowels. In this section, alternation patterns of 13 participants are classified based on the direction of paradigm leveling: bidirectional vs. unidirectional. Within directions, patterns are subcategorized in terms of the degree of paradigm leveling.

In the GMM fitting figures presented in sections 4.1 and 4.2, blue bars represent suffix-initial vowels after stem-final /a, o/ conditions, and red bars represent suffix-initial vowels after stem-final /ə, u, ɨ, i/ conditions. Following the original Korean vowel harmony rule, blue bars must be classified as being /a/-like (negative log ratio of the center of a curve, or left of the cross-point of two curves) and red bars as being /ə/-like (positive log ratio of the center of a curve, or right of the cross-point of two curves).

4.1 Bidirectional Paradigm Leveling

4.1.1 Fully bidirectional

Two participants, 6 and 15 show fully bidirectional paradigm leveling of suffix-initial vowels in their responses. They allow disharmonic suffixes after every stem-final condition.

Table 3. Categorization results of participants 6 and 15

Stem-final	/a/-like %	/ə/-like %
a	43.51	**56.49**
o	58.88	**41.12**
ə	**9.2**	90.8
u	**10.53**	89.47
ɨ	**22.39**	78.61
i	**23.72**	77.28

Figure 3. Distribution of suffix-initial vowels showing fully bidirectional paradigm leveling

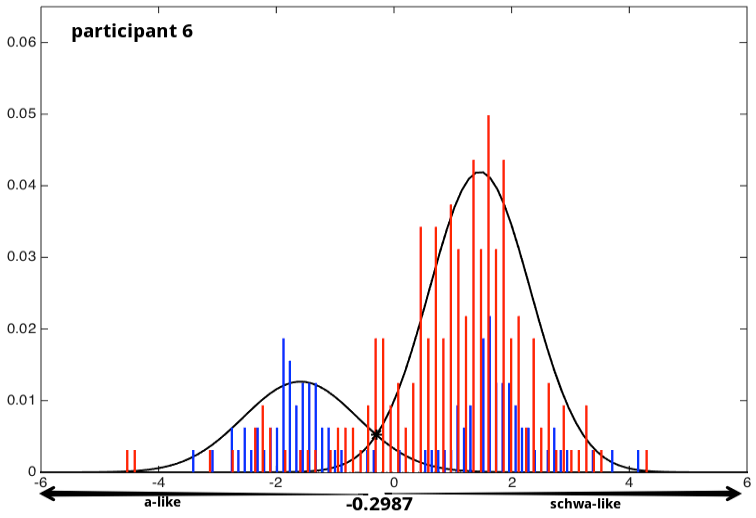


Table 3 shows the categorization results of suffix-initial vowels produced by the participants. On average, over 40% of suffix-initial vowels produced after stem-final /a, o/ conditions are categorized as being disharmonic /ə/-like, and 9~24% of suffix-initial vowels after other stem-final vowel conditions are categorized as being disharmonic /a/-like.

In Figure 3 showing categorization results of participant 6, suffix-initial vowels after stem-final /a, o/ conditions (blue bars in the figure) are included in both /a/-like and /ə/-like clusters

across the cross-point between the two Gaussian curves. Suffix-initial vowels after other stem-final vowel conditions (red bars) are also included in both two clusters. Participant 15 shows a similar pattern.

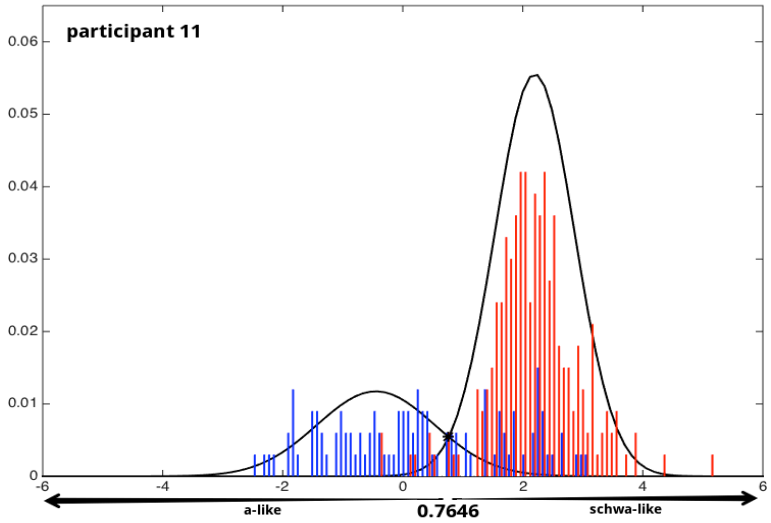
4.1.2 Minimally Bidirectional & Almost Unidirectional to /ə/

Five participants, 1, 10, 11, 12, and 14 show bidirectional paradigm leveling of suffix-initial vowels in their responses, but the degree of bidirectionality is minimal. The pattern seems to be almost unidirectional paradigm leveling, especially to /ə/.

Table 4. Categorization results of participants 1, 10, 11, 12, and 14

stem-final V	/a/-like %	/ə/-like %
a	76.04	**23.96**
o	47.5	**52.5**
ə	**0.97**	99.03
u	**2.61**	97.39
ɨ	**1.87**	98.13
i	**2.24**	97.76

Figure 4. Distribution of suffix-initial vowels produced by participant 11



As shown in Table 4, suffix-initial vowels after stem-final /a, o/ conditions are categorized as being disharmonic /ə/-like about 24~53%. After other stem-final conditions, only about 2~3% of suffix-initial vowels are categorized as being disharmonic /a/-like. In that sense, paradigm leveling in this pattern is minimally bidirectional and almost unidirectional to /ə/.

In Figure 4, suffix-initial vowels after stem-final /a, o/ conditions (blue bars) are included in both /a/-like and /ə/-like clusters across the cross-point between the two Gaussian curves. However, only a few suffix-initial vowels after other stem-final vowel conditions (red bars) are included in the disharmonic /a/-like cluster, but they are quite close to the /ə/-like cluster.

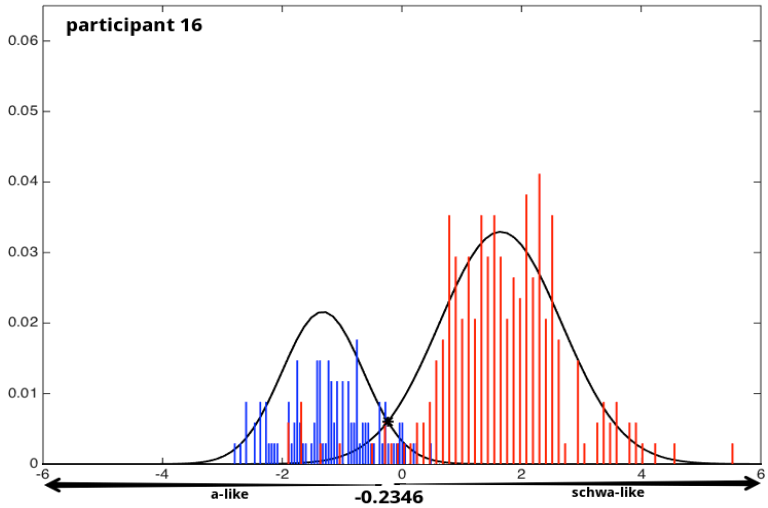
4.1.3 Minimally Bidirectional & Almost Unidirectional to /a/

Participant 16 shows the opposite direction of minimally bidirectional paradigm leveling of suffix-initial vowels. As in Table 5, suffix-initial vowels after stem-final /a, o/ conditions and after other remaining conditions are categorized as being disharmonic with similar percentages.

Table 5. Categorization results of participants 16

stem-final V	/a/-like %	/ə/-like %
a	87.04	**12.96**
o	94.44	**5.56**
ə	**0**	100
u	**1.59**	98.41
ɨ	**0**	100
i	**17.31**	82.69

Figure 5. Distribution of suffix-initial vowels produced by participant 16



In terms of the distribution of suffix-initial vowels in Figure 5, suffix-initial vowels categorized as being disharmonic /ə/-like after stem-final /a, o/ conditions (blue bars right to the cross-point) are quite close to the /a/-like cluster left of the cross-point. In contrast, disharmonic suffix-initial vowels after other stem-final vowel conditions (red bars left to the cross-point) are really /a/-like. For this reason, paradigm leveling in this pattern is minimally bidirectional and almost unidirectional to /a/.

4.2 Unidirectional Variations

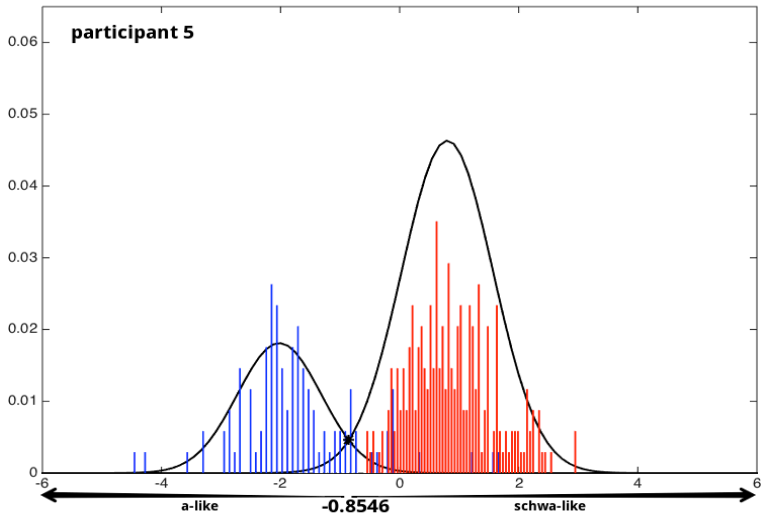
4.2.1 Ongoing Unidirectional to /ə/

Participants 3 and 5 show ongoing unidirectional paradigm leveling to /ə/. As shown in Table 6 and Figure 6, suffix-initial vowels only after stem-final /a, o/ conditions are categorized into two different clusters.

Table 6. Categorization results of participants 3 and 5

stem-final V	/a/-like %	/ə/-like %
a	83.09	**16.91**
o	70.37	**26.63**
ə	**0**	100
u	**0**	100
ɨ	**0**	100
i	**0**	100

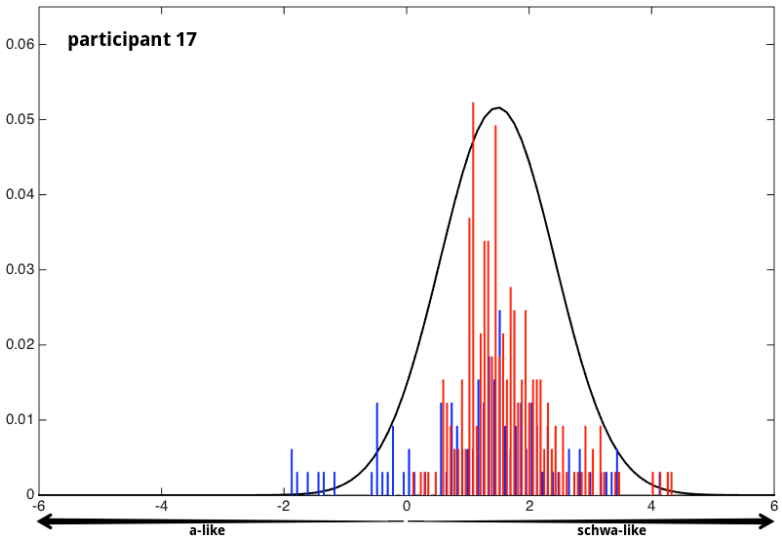
Figure 6. Distribution of suffix-initial vowels produced by participant 5



4.2.2 Completed Unidirectional to /ə/

The last three participants, 4, 7, and 17 show the completed unidirectional paradigm leveling of suffix-initial vowels to /ə/. Suffix-initial vowels produced by these participants show a unimodal distribution as shown in Figure 7. Data fits a single Gaussian curve, not two curves as shown before. Since the center of the curve has a positive log ratio, all of the suffix-initial vowels are categorized as being /ə/-like.

Figure 7. Distribution of suffix-initial vowels produced by participant 17



4.3 Statistical Analysis

In order to check the statistical significance of the categorization results, a Generalized Linear Mixed-Effects model is fitted to the data. All of the suffix-initial vowels produced by 13 participants are included in the analysis. In the model, stem-final vowel conditions predict binomial categorization results (/a/-like vs. /ə/-like) with fixed effects of stem types (existing vs. nonce) and stem-final vowels (/a, o, ə, u, ɨ, i/) as well as with random effects of participants. The open source statistic software *R* (R development core team, 2008) is used to create the statistical model for the current data. The result of the model fitting is as follows:

```
Random effects:
 Groups      Name        Variance Std.Dev.
 participant (Intercept) 8.509    2.917
Number of obs: 4368, groups:  participant, 13

Fixed effects:
                 Estimate Std. Error z value Pr(>|z|)
(Intercept)      -2.97965    0.83569  -3.566 0.000363 ***
stemtypeNonce    -0.84291    0.12102  -6.965 3.29e-12 ***
finalVAOvsOthers -0.67203    0.02272 -29.584  < 2e-16 ***
finalVAvsO       -0.30385    0.06730  -4.515 6.33e-06 ***
finalVIvsEUWU    -0.21154    0.05377  -3.934 8.34e-05 ***
finalVEvsUWU      0.25178    0.10277   2.450 0.014288 *
finalVUvsWU      -0.27534    0.14607  -1.885 0.059439 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

The model indicates that existing and nonce stems show significantly different patterns of categorization of produced suffix-initial vowels. Stem-final vowels show significant differences in categorization results: stem-final /a, o/ vs. other vowels, /a/ vs. /o/, /i/ vs. /ə, ɨ, u/, /ə/ vs. /ɨ, u/, and /ɨ/ vs. /u/.

We can see the different patterns in Figure 8 and 9 below. In these figures, 'e' represents stem-final /ə/, 'u' is /ɨ/, and 'wu' is /u/. Since a-like categorization is coded as 1 and ə-like as 0, higher values mean that suffix-initial vowels produced after the corresponding stem-final condition are more a-like. In Figure 8, existing (red-colored line) and nonce stems (blue-colored line) show different patterns of categorization. In addition, stem-final /a, o/ and other vowel conditions show different patterns. Most of suffix-initial vowels after stem-final /a, o/ are a-like. In contrast, most of them after other stem-final vowels are ə-like. Stem-final /a, o/ allows more ə-like disharmonic suffix-initial vowels with nonce stems than existing ones, but they show significantly different patterns. Stem-final /o/ is more conservative with existing stems than /a/, but /o/ allows more disharmonic suffix-initial vowels than /a/ with nonce stems.

Figure 8. Categorization results across stem-final /a, o, ə, u, ɨ, i/

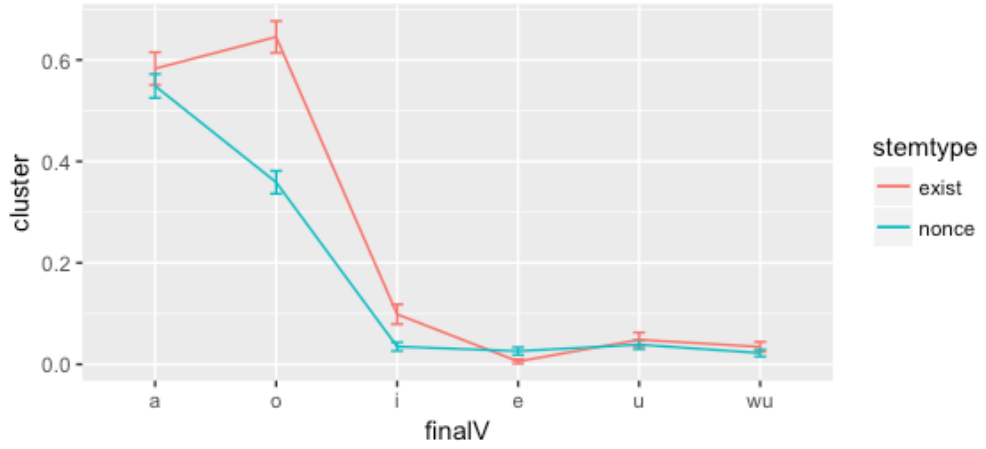
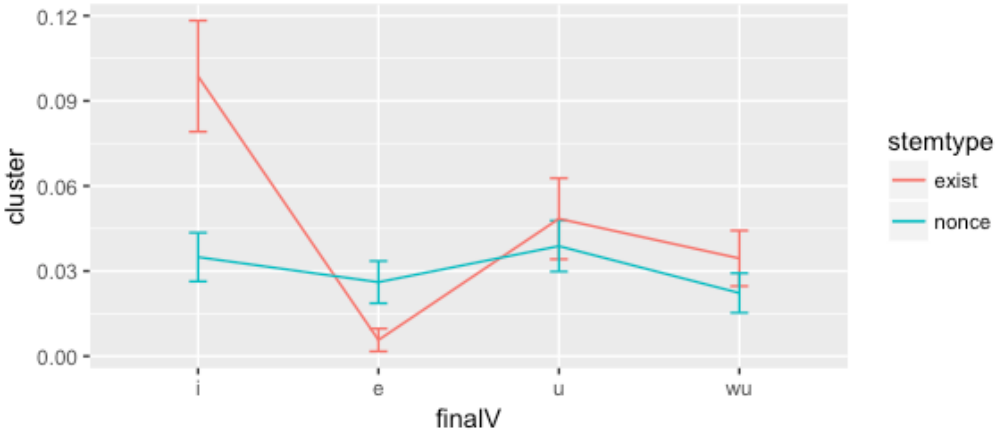


Figure 9 is a close-up of stem-final /ə, u, ɨ, i/ in Figure 8. Except for /ə/, they allow more a-like disharmonic suffixes with existing stems. Stem-final /i/ shows the largest difference in categorization between existing vs. nonce stems. With existing stems, more a-like disharmonic suffixes are allowed after /i/. In contrast, stem-final /ə/ allows more disharmonic suffixes with nonce stems. Stem-final /ɨ/ and /u/ show similar patterns, but /ɨ/ allows more disharmonic suffixes than /u/ overall.

Figure 9. Categorization results across stem-final /ə, u, ɨ, i/



5 Discussion and Conclusion

The experimental results show that the decay of Korean vowel harmony is bidirectional not only across participants but also within participants. This supports the hypotheses 2 and 3 presented in the second section.

Zadok and Bat-El (2015) argue that what determines the directionality of paradigm leveling (unidirectional vs. bidirectional) is the ratio of the size of the two target paradigms. Here the size of a paradigm is the type frequency of verbs and adjectives included in the paradigm. They argue that a large ratio leads to unidirectional paradigm leveling to the highly populated paradigm, and a small ratio to bidirectional leveling.

Table 7. Size ratio of /ə/-harmonic over /a/-harmonic paradigms in Korean

stem-final vowel	a	o	ə	u	ɨ	i	e	ɛ	y	ø
type frequency	1046	386	990	380	459	4089	26	545	2698	49
total by paradigm	1432		9236							
size ratio	6.44972067									

Table 7 shows the size ratio of /ə/-harmonic paradigm over /a/-harmonic paradigm calculated based on stem-final vowels of verbs and adjectives listed in the Sejong Korean dictionary. There are 9730 /a/-final verbs and adjectives in the dictionary, but among them, 8684 are noun+-*ha* 'noun+do' forms. Since the forms show irregular suffixation forms (usually noun+-*hɛ*), they are excluded in the counting.

Following Zadok and Bat-El (2015), the size ratio 6.45 is judged as a low ratio. The low ratio means that the size of the two target paradigms is not different enough to select an obvious winner in paradigm leveling. As a result, bidirectional paradigm leveling could happen across or within participants in the decay of Korean vowel harmony.

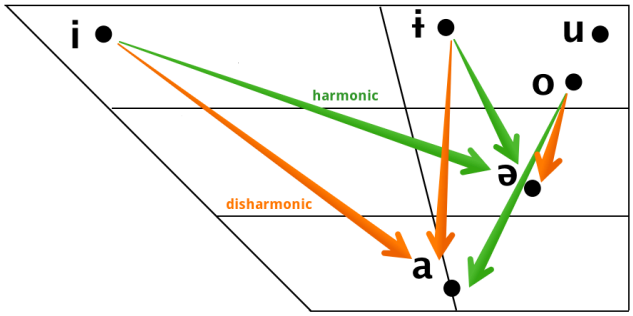
In the current experimental results, various patterns with different directionality and degrees of paradigm leveling are observed across participants. These findings show that there are many possible paths to re-generalize an ungrounded rule even in the same generation of speakers of the same dialect.

Consequently, the following question arises: what is the new criterion for the re-generalization of Korean vowel harmony as an ungrounded rule? One possible criterion is frontness of stem-final vowels. Different degrees of variation across stem-final vowel conditions within the same paradigm are also observed. Within the /a/-harmonic paradigm, the stem-final /o/ condition showed more variation than the /a/ condition in average: for ten participants showing bimodal distributions of suffix-initial vowels, 40.96% of suffix-initial vowels after stem-final /o/ condition were categorized as being disharmonic /ə/-like (vs. 27.96% after stem-final /a/ condition). Within the /ə/-harmonic paradigm, the stem-final /i/ condition showed the most variations relative to other conditions: for ten participants, 7.6% of suffix-initial vowels after the condition were categorized as being disharmonic /a/-like. The next highest percentage of variations was 5.41% after stem-final /ɨ/ condition (the other two remaining conditions showed 2.32~3.57% of variations).

Figure 10 shows harmonic (green-colored arrows) vs. disharmonic (orange) selection of suffix-initial vowels after stem-final /o, i, ɨ/ conditions based on the vowel chart of

Contemporary Korean. The further back the vowel (/o/), the more likely it is to take disharmonic /ə/-initial suffixes in the /a/-harmonic paradigm. The further front the vowel (/i, ɨ/), the more likely it is to take /a/-initial suffixes in the /ə/-harmonic paradigm.

Figure 10. Harmonic vs. disharmonic selection of suffix-initial vowels after stem-final /o, i, ɨ/



If this interpretation is correct, it means that Korean shows the RTR-to-palatal shift of vowel harmony, since in Middle Korean the vowel harmony was RTR-based. At a glance, this seems opposite to the conventional argument that Mongolian undergo palatal-to-RTR vowel contrast and harmony shift (Svantesson 1985). However, Vaux (2009) points out that the palatal-to-RTR vowel shift lacks phonetic support. In contrast, since tongue root retraction entails tongue body movement (Archangeli and Pulleyblank 1994), the RTR-to-palatal shift is a phonetically-grounded simplification. Based on the idea, Vaux (2009) proposes to reconstruct an RTR-based vowel system for Proto-Altaic, and Ko (2012) attempts to reconstruct an RTR system for Old Mongolian. In that sense, Korean and Altaic languages show the same direction of vowel harmony shift, RTR-to-palatal.

However, the frontness of stem-final vowels as a criterion for re-generalization of Korean vowel harmony is not that strong. Especially in the case of /i/, the reason why it shows the highest percentage of disharmonic suffix-initial vowels in the same paradigm could be because /i/ was a neutral vowel in Middle Korean vowel harmony. That is, from the beginning, /i/ could have been as likely to move towards one direction as it was to move towards the other. Thus, this last question on the criteria of the re-generalization of Korean vowel harmony remains open and further inquiry is warranted; this issue should hopefully be re-visited in future work.

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