Front Vowel Raising and Opacity in Čənnam Dialect*

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Seo, Jeong-min & Jo, Hak-haeng. 2007. Front Vowel Raising and Opacity in Čənnam Dialect. *The Linguistic Association of Korea Journal (15)*3, 89-108. The purpose of this paper is to investigate the opacity of front vowel raising in central and western part of a Čənnam Dialect circle (ČD, henceforth). Opacity, which refers to the phenomenon that output forms are shaped by generalizations that are not surface-true, or not surface-apparent, has been a challenge to classic Optimality Theory (OT, henceforth; Prince & Smolensky 1993) since it does not allow intermediate level of derivation. Local Conjunction (LC, henceforth; Smolensky 1993, 1995, 1997) and Sympathy Theory (ST, henceforth; McCarthy 1999, 2002) have been proposed to deal with opacity but there are also problems in them. In this paper to resolve the problem in OT, LC, and ST, we will attempt to solve the opacity problem by employing the new account of recently proposed Optimality Theory with Candidate Chains (OT-CC, henceforth; McCarthy 2006a, 2006b), which incorporates inter-candidate derivational information with P_{REC}(edence) constraints(A, B) (P_{REC}(A, B), henceforth). Based on OT-CC with Prec(A, B), this paper examines and analyses the opacity of front vowel raising, in which rule order produces a kind of underapplication resulting from counterfeeding rules and supports the superiority of OT-CC.

Key words: opacity, ČD, OT, LC, ST, OT-CC, P_{REC}(A, B), counterfeeding underapplication, overapplication, chain shift

1. Introduction

OT differs from the rule-based theories in that it does not allow serial derivations.[1] The output-based OT is based on parallel

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implementation. In OT, the relationship between input and output is defined as a direct mapping. Constraints in OT are categorized in two groups: faithfulness and well-formedness constraints. The former constraints refer to both input and output simultaneously and penalize any possible candidates that undergo phonological changes from their corresponding input. The latter constraints, however, are output-based in that they never refer to input in evaluating output candidates.

In terms of rule-based application, opacity can be found in two cases: overapplication and underapplication. The former refers to the case where a process applies even though its context is not present at the surface. Contrary to the former, the latter refers to the case where a process does not apply even though its context is present at the surface.

According to Kiparsky (1973: 79), opacity is defined as follows.

(1) A phonological rule P of the form A → B / C ___ D is opaque if there are surface structures with either of the following characteristics:
  a. instances of A in the environment C ___ D.
  b. instances of B derived by P that occur in environments other than C ___ D.

As shown in (2), the case of (1a) is found in *t*-Palatalization in Korean, in which /t/ and /t^h/ become palatalized before /i/ to be neutralized to [c] and [c^h], respectively.[2)]

(2) Underapplication in Korean (Kim 2003: 172)

a. mati	'knot'	[ma.di]
b. mat-i	'eldest'	[ma.ji]

Contrary to (2b), (2a) does not undergo *t*-Palatalization, although

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1) For the detailed discussion on OT, refer to Prince & Smolensky (1993).

2) According to Kim (2003: 172), the neutralized [c] becomes [j] by Voicing Assimilation, whereby voiceless stops get voiced between voiced segments. And in (2), the dot in the surface form represents a syllable boundary.

there is a sequence of [di]. The rule underapplies, resulting in a case of opacity.

The case of (1b) is shown in Bedouin Arabic. In this language, palatalization does not allow /ki/ sequence, thus /k/ becomes a palatalized [k^j] before /i/. And in this language, syncope requires a short high vowel to be deleted in a non-final open syllable.

(3) Overapplication in Bedouin Arabic (McCarthy 2006b: 4)

UR	/ħa:kim-i:n/	'ruling (masculine plural)'
Palatalization	ħa:k^jimi:n	
Syncope	ħa:k^jmi:n	
SR	[ħa:k^jmi:n]	

However, the surface form [ħa:k^jmi:n] in (3) does not tell us why palatalized [k^j] occurs. That is, palatalization is overapplied even though the application is not motivated in the surface environment.

Of the two kinds of opacity, we are concerned with (1a) in this study, in which opacity results from counterfeeding rule.

The purpose of this paper is to investigate the opacity of front vowel raising in ČD. For this, we will first analyse front vowel raising in ČD: /ɛ/ to [e] and /e/ to [i]. And we will show that the previous theoretical analyses in the framework of OT, LC, and ST cannot consistently explain the opacity problem which is related to front vowel raising in ČD. Following that, we will analyse the opacity in the framework of McCarthy's (2006a, 2006b) recently proposed OT-CC, which incorporates inter-candidate derivational information with P_{REC}(A, B). By doing so, we will show the merits of OT-CC in analysing the opacity of front vowel raising in ČD.

This paper is organized as follows. Section 2 provides introductory remark about the opacity of front vowel raising in ČD. Section 3 provides the previous theoretical analyses of the opacity in OT, LC, and ST. In section 4, after briefly introducing OT-CC, we will analyse the opacity within the framework of OT-CC. Section 5 is a concluding summary.

2. Data Analysis

According to Kiparsky (1973) as shown in section 1, phonological processes are opaque if their effects or their contexts are not visible in surface forms. The case we will investigate in this paper is called a non-surface-true one, which underapplies even when an appropriate context is present on the surface. The case, which is a kind of chain shift, is illustrated from vowel raising in ČD.[3)] In ČD, low vowel and mid vowel are raised by one degree, respectively as shown in (4).

(4) Vowel raising in ČD[4)]

kɛ(ga)[5)]	'dog'	ke(ga)	'crab'	>	ki(ga)
nɛ(ga)	'I'	ne(ga)	'you'	>	ni(ga)
nɛ (gət̚)	'mine'	ne (saɾam)	'four people'	>	ni (saɾam)
tɛ(da)	'to attach'	te(da)	'to get burnt'	>	ti(da)
t'ɛ(da)	'make a fire'	t'e(da)	'remove'	>	t'i(da)
mɛ(da)	'tie up'	me(da)	'to feel choked'	>	mi(da)
pɛ(da)	'to get pregnant'	pe(da)	'to cut'	>	pi(da)
sɛ(da)	'to leak out'	se(da)	'to be strong'	>	si(da)
sɛ(maɨl)	'a new community'	se (maɨl)	'three villages'	>	si (maɨl)
čɛ(ga)	'he or she'	če(ga)	'I (honorific)'	>	či(ga)

In (4), low and mid vowels are raised by on degree: /kɛ(ka)/ ('dog') is raised to [ke(ga)] and /ke(ka)/ ('crab') to [ki(ga)]. However, low vowels are never raised to high vowels.

According to Ki (1981), we assume the following specifications for vowels for [low], [mid], and [high] in Korean as shown in (5).

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3) For the detailed discussion on chain shift, refer to Kenstowicz & Kisseberth (1979), Kirchner (1996), Kager (1999), and Chae (1997, 2001).

4) For more detailed data, which are related to front vowel raising in ČD, refer to Ki (1981), Chae (1997, 2001), and Kang (2005).

5) In Korean, voiceless obstruents become voiced between sonorants. In this paper, we will ignore this process as it is not directly related to the present study.

(5) Korean's vowel specifications (Ki 1981: 5-7, 21)[6)]

High: ㅣ/i/	[-low, +high]
Mid: ㅔ/e/	[-low, -high]
Low: ㅐ/ɛ/	[+low, -high]

In rule-based theory, the analysis is straightforward. It is a case of counterfeeding. Two counterfeeding rules raise low and mid vowel, respectively as shown in (6).

(6) Counterfeeding opacity of chain shift

a. Mid to high

UR	/ke/	'crab'
Mid Vowel Raising	ki	
Low Vowel Raising	___	
SR	[ki]	

b. Low to mid

UR	/kɛ/	'dog'
Mid Vowel Raising	__	
Low Vowel Raising	ke	
SR	[ke]	

In (6), each of the counterfeeding rules applies only once per derivation. In (6a), Mid Vowel Raising changes /e/ to [i]. In (6b), however, this rule does not apply to vowel [e] on the surface form [ke] ('dog'). In (6b), the structural context of a rule is potentially satisfied due to the application of a prior rule Mid Vowel Raising. But the ordering is such that only one rule applies. The second rule Low Vowel Raising, which might have created the context of application for the first rule, applies too early to actually feed it. Such counterfeeding rule order creates the opacity of [ke] ('dog') in ČD.[7)]

6) /ɛ/ and /e/ are neutralized as [e] in ČD (Kang 2005: 11). Thus as shown in (4), /kɛ/ ('dog') and /ke/ ('crab') are realized as [ke] ('dog') and [ke] ('crab'), respectively in ČD.

As shown in (6) chain shift is not problematic to serial theory. However, it poses problems to OT, LC, and ST, which we will show in section 3.

3. Previous Theoretical Analysis

In this section, let us analyse chain shift, a kind of underapplying opacity of [ke] ('dog') under OT, LC, and ST in order.

As seen in (6b), phonological opacity can be rather easily handled in serial rule-based approach. In non-serial mechanism of OT approach, however, phonological opacity that involves a decisive role of non-surface-true intermediate form in deriving a correct output form raises a serious problem. In two-level system of OT operating only with underlying input and surface-true outputs, such an existence of an intermediate form originated from the derivational system is an unwanted component of phonology that should not be accepted. Tableau (8) clearly indicates that the account of the counterfeeding type of opacity shown in (6b) is problematic for OT analysis. For a detailed discussion on (8), the relevant constraints for OT analysis are presented in (7).

(7) Relevant constraints in OT analysis

a. Vowel Raising 1: VR 1
Raise low vowel to mid vowel, or mid vowel to high vowel.

b. Vowel Raising 2: VR 2
Raise low vowel to high vowel.

c. IDENT-IO[+Low]: IDENT-IO[L]
If an input segment is [+Low], then its output correspondent is [+Low].

d. IDENT-IO[+Mid]: IDENT-IO[M]
If an input segment is [+Mid], then its output correspondent is [+Mid].

7) For the detailed discussion on counterfeeding order, refer to Kager (1999: 375-377).

(7a) and (7b) are well-formedness constraints. Vowel raising is triggered by these constraints.[8] (7c) and (7d) are basic faithfulness constraints that evaluate featural identity between corresponding segments in the input and the output. In ČD, for vowel raising to take place, VR 1 and VR 2 must be ranked above both faithfulness constraints. That is, /ɛ/ → [e] shows that IDENT-IO[L] is dominated, while /e/ → [i] shows that IDENT-IO[M] is dominated. As discussed at the beginning of this section, in the perspective of OT, what is most problematic is that constraint interaction system of input-output corresponding relation cannot provide a correct output form in the opaque case. What would be selected as a winning candidate is not an actual output form that is opaque, but a wrong transparent candidate. This is summarized in the following tableau (8)[9]

(8) OT analysis of opacity problem

/ɛ/	VR 1	VR 2	IDENT-IO[L]	IDENT-IO[M]
a i . ɛ	*!	*		
☞a ii . e (opaque)		*!	*	
☜a iii . i (transparent)			*	
/e/				
b i . e	*!			
☞b ii . i				*

In (8a), the first two candidates cause a fatal violation of relatively

8) For more detailed well-formedness constraints, which are related to vowel raising, refer to Kirchner (1995: 5), Karger (1999: 394), and McCarthy(2006b: 4).
9) The symbol ☜ represents an unintended winning candidate that is not an actual output form.

highly ranked constraints VR 1 and VR 2 and thus, are eliminated. As a result, this ranking incorrectly chooses (8a, iii), which is raised from /ɛ/ to [i], going two steps rather than one, as an optimal form. The incorrect result in (8a) is due to undominated well-formedness constraints VR 1 and VR 2. No reranking of the four constraints allows /ɛ/ → [e], and /e/ → [i], while disallowing /ɛ/ → [i]. That is, /ɛ/ → [i] in (8a, iii) cannot be prohibited from going all the way to being raised.

To sum up, in the perspective of OT, what is most problematic is that the constraint interaction system of input-output corresponding relation cannot provide a correct output form in the opaque case as in (8a). What would be selected as a winning candidate is not an actual output form which is opaque, but a wrong transparent candidate as in (8a, iii).

Another device to be considered is LC. According to Kager (1999), a locally conjoined constraint C in LC is violated iff both of its conjuncts, C_1 and C_2, are violated in a local domain D. Consider the following tableau (9), which contains candidates showing the combinations of violations of constraints C_1 and C_2.

(9) Violation of a locally conjoined constraint in LC (Kager 1999: 393)

	C_1	C_2	$[C_1 \& C_2]_\delta$
a. candidate 1			
b. candidate 2		*	
c. candidate 3	*		
d. candidate 4	*	*	*

In (9), for a violation of $[C_1 \& C_2]_\delta$ to occur both separate violations must arise within a single domain δ (a segment, morpheme, etc.). Evidently some domain is needed for conjunction: the severity of output ill-formedness is never increased by combinations in random positions in the output. And a conjoined constraint $[C_1 \& C_2]_\delta$ does not replace its components C_1 and C_2, but it is separately ranked as shown in (10).

(10) Ranking schema in LC

$[C_1 \& C_2]_\delta >> C_1, C_2$

According to Kager (1999: 395-396), the reasoning behind the analysis of chain shift in the framework of LC is that the change in (9d) involves violation of two faithfulness constraints, while the change in (9b-c) involves only one violation. Then to explain chain shift in Čənnam Dialect of Korean, what is needed is the conjunction of both faithfulness constraints into a composite constraint. This constraint must be ranked above Ident-IO[L] and Ident-IO[M] as shown in (11) to restrict raising to a one-step process.

(11) [Ident-IO[L] & Ident-IO[M]]$_\delta$ >> [Ident-IO[L], Ident-IO[M]

To find out whether LC can solve the opacity in ČD resulting from chain shift, let's look at tableau (8) again. For LC to work out, there should be a conjoined constraint from the lower two constraints Ident-IO[L] and Ident-IO[M], so that the conjoined constraint can choose the opaque candidate (8a, ii) over the transparent candidate (8a, iii).

To see what it would be like when Ident-IO[L] and Ident-IO[M] were conjoined, let's look at tableau (12).

(12) LC analysis of opacity problem

/ɛ/	[Ident-IO[L] & Ident-IO[M]]$_\delta$	VR 1	VR 2	Ident-IO[L]	Ident-IO[M]
a i . ɛ		*!	*		
☞a ii . e			*!	*	
☜a iii . i				*	
/e/					
b i . e		*!			
☞b ii . i					*

In (12), the conjoined constraint [Ident-IO[L] & Ident-IO[M]]$_\delta$ is ranked higher than IDENT-IO[L] and IDENT-IO[M]. However, this is impossible since, like in (12), the combination of two constraints itself is not possible. Therefore, LC cannot consistently explain chain shift in Čənnam Dialect of Korean.

Now, let's discuss why ST cannot deal with chain shift in Čənnam Dialect of Korean.

ST of McCarthy (1999, 2002) is based on the faithfulness relation between a winning candidate and a certain failed candidate. In ST, what sympathy indicates is the phonological influence of a particular candidate, which is more faithful to the input, or the winning output, which is mediated by a unique relation of faithfulness. Under such notion of sympathetic faithfulness, the opaque form is expected to be selected as a winning output form over a transparent form as it closely resembles a failed candidate. In other words, there is another type of faithfulness relation, which operates between candidates. In this way, the occurring output form is in sympathy with a particular failed candidate. The choice of the particular failed candidate, referred to as the sympathetic candidate that is indicated by the symbol ❀, cannot be random, but should be the one that obeys a certain designated faithfulness constraint, which is indicated by the symbol ★.

Another crucial constraint in the sympathy analysis is the sympathetic faithfulness constraint that is indicated by the symbol ❀. This sympathetic faithfulness constraint directly captures the connection between the sympathetic candidate and the winning candidate. This sympathetic faithfulness constraint requires all the other candidates to be faithful to the sympathetic candidate. That is, the candidate-to-candidate faithfulness is directly exposed by the role of the sympathetic faithfulness constraint.

To account for opacity of chain shift in /ε/ → [e], the output must be maximally faithful to a ❀-candidate that is not raised. Therefore ★ IDENT-IO[M] must be the selector constraint, and [e] the ❀-candidate. Assuming IDENT-❀O[M] as the undominated ❀O-faithfulness constraint, we arrive at tableau (13a).

(13) ST analysis of opacity problem

/ɛ/	IDENT-❀O[M]	VR 1	VR 2	IDENT-IO[L]	★IDENT-IO[M]
a i . ɛ	*!	*	*		
☞❀a ii . e			*	*	
a iii . i	*!			*	
/e/					
☜❀b i . e		*			
☞b ii . i	*!				*

As the above tableau shows, it is the sympathetic faithfulness constraint IDENT-❀O[M] that selects the opaque form (13a, ii) over the transparent form (13a, iii) as the winning output form in (13a). In (13b), however, we see that the same ranking predicts that [e] is the ❀-candidate, hence the wrongly chosen output. Reversing the ranking of IDENT-❀O[M] and the well-formedness constraints cannot select the correct output.

4. Optimality Theory with Candidate Chains and Vowel Raising

Unlike OT, LC, and ST, OT-CC with Prec(A, B) records the history of faithfulness violation in forming valid candidate chain. The winning candidate chain is an ordered *n*-tuple of forms C = $<f_0, f_1, ..., f_N>$ that meets the well-formedness conditions as shown in (14).

(14) Three conditions for well-formedness (McCarthy 2006a: 2)

a. Faithful initial form: f_0 is a faithful parse of /in/. (Specifically, it's the faithful parse of /in/ that's most harmonic according to H.)

b. Gradual divergence: In every pair of immediately successive forms in C, $<..., f_i, f_{i+1}, ...>$ $(0 \leq i < n)$, f_{i+1} has all of f_i's unfaithful mapping, plus one.

c. Harmonic improvement: In every pair of immediately successive forms in C, $<..., f_i, f_{i+1}, ...>$ $(0 \leq i < n)$, f_{i+1} is more harmonic than f_i according to $EVAL_H$.

As shown in (14a), the first form in a chain is identical with the input. Gradual divergence in (14b) requires the successive forms in a chain to be minimally different from their preceding neighbors. Harmonic improvement in (14c) demands that each form in a chain should be more harmonic than its predecessor, relative to the well-formedness constraints.

As stated in McCarthy (2006d: 1-2), he points two main conditions on the validity of candidate chain in a hypothetical language with both postconsonantal epenthesis and intervocalic voicing: gradualness and harmonic improvement. The gradualness requirement limits each chain to making one change at a time. That is, the mapping /pap/ → [pabə] requires a chain with two steps: <pap, papə, pabə>. The chain <pap, pabə> is excluded from the candidate set by the gradualness requirement and it never has a chance to compete for optimality.[10] The harmonic improvement requirement mentions that the successive forms in a chain must increase harmonically, which is relative to the constraint hierarchy of the language. For example, <pap, pab, pabə> is not a valid chain if nothing in the ranking favors voicing of final consonants. That is, the link [pab] is not more harmonic than [pap] according to this language′s constraint hierarchy.

In OT-CC, both faithfulness and markedness constraints play the same role as they have done in OT. The faithfulness constraints evaluate input-output relation (initial-final forms in chain), while the well-formedness constraints evaluate the output (final form in chain).

McCarthy (2006a) proposes a new kind of constraint, PREC(A, B), which is defined as follows.

(15) PREC(A, B) (McCarthy 2006a: 10)

Let A′ and B′ stand for forms that add violations of the faithfulness constraints A and B, respectively.

To any chain of the form <X, B′, Y>, if X does not contain A′, assign a violation mark, and

10) For the detailed discussion on the gradualness and harmonic improvement, refer to McCarthy (2006a: 2; 2006b: 2-4; 2006d: 16).

to any chain of the form <X, B′, Y>, if Y contains A′, assign a violation mark.

Prec(A, B) in (15) says that the violation of constraint B requires that of constraint A beforehand. That is, in a chain <X, B′, Y>, constraint A should be violated first and then the violation of constraint B should be followed. If the order of faithfulness constraint violation is reversed or violation of constraint A is skipped, the candidate chain under question gets violation marks.

For the convenience of understanding OT-CC, let us briefly consider another kind of underapplication opacity resulting from counterfeeding rule in Bedouin Arabic.

(16) Counterfeeding order in Bedouin Arabic (McCarthy 2006b: 4)

Mid to high		
UR	/gabr/	'a grave'
Raising (a → i/ ___ CV)	____	
Vowel Epenthesis (∅ → V/ ___ C#)	gabur	
SR	[gabur]	

According to McCarthy (2006b), Raising raises /a/ to [i] in a non-final open syllable in Bedouin Arabic. As shown In (17), however, /a/ is not raised to [i] on the surface form [gabur], which results in a case of underapplication. In (16), the rule order of Raising before Vowel Epenthesis, which is a kind of counterfeeding order, leads to an opaque surface form, where Raising underapplies on the surface.

McCarthy (2006b) shows that surface-oriented OT is caught in a dilemma selecting a wrong output form as shown in tableau (17b).

(17) McCarthy (2006b: 4)

a. Relevant constraints in OT analysis

i. *Complex-Coda- violated by final cluster in *[gabr].

ii. Raise- violated by any [a] in a nonfinal syllable such as [ga.bur].

iii. Dep- no epenthesis.

iv. Ident(low)- no raising.

b. OT analysis of opacity problem in Bedouin Arabic

/gabr/	Raise	*Complex-Coda	Ident(low)	Dep
☜ i. gi.bur			*	*
☞ ii. ga.bur	*!			*
iii. gabr		*!		

In tableau (17b), there is a gap between a real output form and an unattested output form selected by constraints and their ranking. Candidates (17b, ii–iii) cause a fatal violation of relatively highly ranked constraints Raise and *Complex-Coda and thus, are eliminated. As a result, this ranking incorrectly chooses (17b, i), which is raised in a non-final open syllable, as an optimal form.

With well-formedness conditions in (14) and Prec(A, B) in (15), McCarthy (2006b) proposes a new analysis of [gabur] ('a grave') in the framework of OT-CC as shown in (18c). Valid candidate chain from [gabur] ('a grave') is shown in (18b, ii) with Prec(A, B) given in (18a).

(18) McCarthy (2006b: 4, 25-26)

a. Prec(Ident(low), Dep)

Mid to high		
UR	/gabr/	'a grave'
Raising (a → i/ ___ CV)	___	
Vowel epenthesis (∅ → V/ ___ C#)	gabur	
SR	[gabur]	

b. Valid candidate chain from /gabr/, given ranking in (18a)

i. <gabr>

ii. <gabr, ga.bur> √

iii. <gabr, ga.bur, gi.bur>

c. OT-CC analysis of opacity problem

/gabr/	*Complex-Coda	Prec (Ident(low), Dep)	Raise	Ident(low)	Dep
☞ i . <gabr, ga.bur> <Dep>		*	*		*
ii . <gabr, ga.bur, gi.bur> <Dep, Ident(low)>		**!		*	*
iii. <gabr> <>	*!				

In (18b), the valid chain should be (18b, ii), which reflects derivational information as shown in (16) and (18a).[11] Candidate chain (18b, i) does not change at all and it has no violation of faithfulness constraints, while it violates markedness constraint *Complex-Coda. Candidate chain (18b, ii) violates faithfulness constraint Dep. Candidate chain (18b, iii) violates not only Ident(low) but also Dep. The only way to select (18b, ii) as an optimal output is to have Prec(Ident(low), Dep) ranked between *Complex-Coda and Raise as shown in (18c). Here, Prec(Ident(low), Dep) requires that the violation of Ident(low) precede that of Dep in candidate chain.

In (18c, i), the last form of candidate chain has one Prec(Ident(low), Dep) violation mark since there is no Ident(low) violation before the existence of Dep violation. (18c, ii) has two violation marks since there is one violation of Dep before Ident(low) violation. (18c, iii) has no change at all. So it does not violate any Prec(Ident(low), Dep). However, it violates the highest constraint *Complex-Coda and is ruled out.

Now we return to the opacity of [ke] ('dog') in ČD. With well-formedness conditions in (14) and Prec(A, B) in (15), we review the opacity of [ke] ('dog') in ČD in the framework of OT-CC.[12] Valid candidate chain from [ke] ('dog') is shown in (19b, ii) with Prec(A, B) given in (19a), whose rule order is repeated here as shown in (6) for convenience's sake.

11) In (18b, ii), the symbol √ represents valid candidate chain.

12) For the detailed discussion on the opacity of Korean in OT-CC, refer to Seo & Jo (2006).

(19) a. PREC(IDENT-IO[M], IDENT-IO[L])

	i . [ki]		ii . [ke]	
UR	/ke/	'crab'	/kɛ/	'dog'
Mid Vowel Raising	ki		___	
Low Vowel Raising	___		ke	
SR	[ki]		[ke]	

b. Valid candidate chain

i . <ɛ>

ii . <ɛ, e> √

iii . <ɛ, e, i>

As mentioned in (6), (19a, i) shows that the first rule Mid Vowel Raising changes /e/ to [i]. In (19a, ii), however, this rule does not apply to vowel [e] on the surface form [ke] ('dog'). The second rule Low Vowel Raising, which might have created the context of application for the first rule, applies too early to actually feed it, resulting from counterfeeding rule order in ČD. PREC(A, B) in (19a) is incorporated into PREC(IDENT-IO[M], IDENT-IO[L]), which inflects the violation order of faithfulness constraints rather than the presence or absence of constraint violation.

In (19b), candidate chain (19b, i) has no change at all and it has no violation of PREC(IDENT-IO[M], IDENT-IO[L]). Valid candidate chain (19b, ii) has one PREC(IDENT-IO[M], IDENT-IO[L]) violation mark since there is no IDENT-IO[M] violation before the existence of IDENT-IO[L] violation. (19b, iii) is even worse than (19b, ii) since it violates PREC(IDENT-IO[M], IDENT-IO[L]) twice.

Equipped with PREC(IDENT-IO[M], IDENT-IO[L]), tableaus in (8), (12), and (13) are revised into tableau (20).

(20) OT-CC analysis of opacity problem

/ɛ/	VR 1	PREC (IDENT-IO[M], IDENT-IO[L])	VR 2	IDENT -IO[L]	IDENT -IO[M]
a i . <ɛ> <>	*!		*		
☞a ii . <ɛ, e> <IDENT-IO[L]>		*	*	*	
a iii . <ɛ, e, i> <IDENT-IO[L], IDENT-IO[M]>		*!*		*	
/e/					
b i . <e> < >			*!		
☞b ii . <e, i> <IDENT-IO[M]>					*

Under the constraint ranking in (20) with PREC(IDENT-IO[M], IDENT-IO[L]) employed, candidates in (20a, ii) and (20b, ii) should be chosen as the optimal forms. (20a, i) is ruled out with the fatal violation of top ranked markedness constraint VR 1. (20a, ii) has one violation mark of PREC(IDENT-IO[M], IDENT-IO[L]) due to no violation of IDENT-IO[M] prior to the violation of IDENT-IO[L]. (20a, iii) has two violation marks of PREC(IDENT-IO[M], IDENT-IO[L]) since there is one violation of IDENT-IO[L] before IDENT-IO[M] violation. As a result, PREC(IDENT-IO[M], IDENT-IO[L]) is violated twice.

To sum up, OT-CC with PREC(A, B) can handle the opacity of [ke] ('dog') in ČD resulting from underapplication and provide a unified analysis. OT-CC allows intermediate derivation by means of candidate chain, where candidates in a chain share violation information of faithfulness constraints one another. PREC(A, B) which is ranked over faithfulness constraints records the violation order of faithfulness constraints.

5. Conclusion

The present study has focused on the underapplication opacity of [ke] ('dog') in ČD resulting from counterfeeding rule, where there is a mismatch between a real output form and a wrongly chosen optimal form in OT, LC, and ST. However, none of these theories can explain the opacity of [ke] ('dog') in ČD. To resolve this problem, we introduced a new theory of McCarthy's (2006a, 2006b) OT-CC.

McCarthy's (2006a, 2006b) recently proposed theory OT-CC employes derivations as a third type of representation and relies on candidate chains, where intermediate forms are arranged in a sequence of gradual divergence and harmonic improvement. And P_{REC}(A, B) reflects the violation order of faithfulness constraints. Based on this proposal, the present study has examined and analysed the opacity of [ke] ('dog') in ČD and supported the superiority of OT-CC.

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