Diachronic Constraint Re-Ranking: Evidence from Japanese

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Abstract

The following analysis uses the framework of Optimality Theory in an attempt to show how the ranking of markedness and faithfulness constraints in Japanese has changed between Old and Modern Japanese in order to create the alternations seen in Modern Japanese verb forms containing the past suffix /ta/. It was originally intended as a synchronic account, which attempted to explain what appeared to be multiple repair strategies for eliminating consonant clusters. However, while researching the topic, I discovered that there is evidence to support the idea that many of the alternations seen with past verbs in Japanese may actually be diachronic in origin, and that they may no longer even be productive in the modern language (see Vance 1985, Ch. 12.6). This discovery prompted me to examine whether the alternations could be analyzed as an "evolution" of the ranking of constraints in the language.

If we assume that Optimality Theory can adequately account for synchronic alternations, then we can likely assume it can adequately account for diachronic alternations as well. Under an Optimality-Theoretic analysis, synchronic alternations are represented by a ranking of markedness and faithfulness constraints, and that being the case, it would seem to follow that we may also represent diachronic alternations in a language as changes in those rankings over time. In this paper, I propose sets of constraint rankings that show the changes that have occurred in Japanese as it has evolved from Old Japanese into Modern Japanese.

Although this paper is intended mainly for linguists who already understand how Optimality Theory works, I have tried to make the paper more accessible for a general audience by including footnotes that briefly explain many of the linguistics terms used throughout the analysis, as well as an appendix that contains a primer on the basic principles and conventions of Optimality Theory.

1. The facts of C-final past form verbs

The following table illustrates the behavior in Modern Japanese of C-final verbs and the past suffix /ta/, based on underlying structures proposed in numerous publications about generative phonology in Japanese:

Table 1: C-final past form verbs

	Underlying	Surface	Gloss
a.	/kat+ta/	[katta]	'win'+PAST
b.	/kar+ta/	[katta]	'rent'+PAST
c.	/kaw+ta/	[katta]	'buy'+PAST
d.	/job+ta/	[jonda]	'call'+PAST
e.	/sin+ta/	[ʃinda]	'die'+PAST
f.	/jom+ta/	[jonda]	'read'+PAST
g.	/kas+ta/	[kaʃita]	'lend'+PAST
h.	/kak+ta/	[kaita]	'write'+PAST
i.	/kag+ta/	[kaida]	'sniff'+PAST

When viewed synchronically, there appear to be six distinct repairs at work in the data above:

Repair strategies:

i. Gemination[1] (in (b) and (c), and vacuously in (a))
ii. Nasalization (in (d))
iii. Epenthesis[2] (in (e))
iv. "Undorsalization"[3] (in (h), and with [voi] spreading in (i))
v. Nasal Place Assimilation[4] (NPA) (in (d), (e), and (f))
vi. Postnasal voicing (in (d), (e), (f), and (i))

These repairs would be motivated by the need to eliminate illegal consonant clusters. But there might not actually be as many repairs as are evident on the surface. To understand why, we need to consider the historical development of C-final

1 The term "gemination" refers to the "doubling" of consonants. This phenomenon is often observed in Japanese, in words like *yappari*, *pittari*, and *hakkiri* (doublings of [p], [t], and [k], respectively).

2 The term "epenthesis" traditionally refers to the adding of segments (i.e. sounds) to an existing string of phonological segments. This phenomenon can be observed in the word [dɪʃɪz], in which the segment [ɪ] appears in the ouput form of the word, but does not appear in its theoretical input form /dɪʃ+z/.

3 I use the term "undorsalization" because the segment corresponding to /k/ in the input is an [i], which is also a [+hi] segment, but does not have actual [dorsal] articulation. As will be shown later, /k/ and [i] are not correspondents.

4 Nasal Place Assimilation is a commonly-observed phenomenon in which a nasal sound's place of articulation is the same as the place of articulation of a consonant that follows it, such as in the words "i[mp]ossible", "i[nd]ifferent", and "i[ŋk]orrect".

past verb forms.

2. Ranking changes in Japanese

In Old (pre-ninth century) Japanese, all syllables had a strict (C)V structure. Syllables of the form /V/ were only allowed word-initially, and long vowels (VV) were not present at all. To ensure this structure, we might assume that the following ranking was present in Old Japanese:

Ranking 1: Old Japanese

*Comp(lex)[5], NoCoda[6], Align[7] (L, PrWd, L, MWd) » Ons(et)[8] » Max, Dep

Tableau 1: CV syllables

	/C1C2VC3/	*Comp	NoCoda	Align	Ons	Max	Dep
a.	.C1C2VC3.	*!	*				
b.	.C1VC3.		*!			*	
c.	.C2VC3.		*!	*		*	
d. ☞	.C1V.					**	

/C1C2VC3/			*Comp	NoCoda	Align	Ons	Max	Dep
.C1V.	~	.C1C2VC3.	W	W	e	e	L	e
C1V.	~	.C1VC3.	e	W	e	e	L	e
C1V.	~	.C2VC3.	e	W	W	e	L	e

The following tableaux show how this ranking allowed both CV and V syllables, while disallowing other types. It seems safe to assume that morphological words in Japanese

5 The *Comp(lex) constraint is meant to represent the sub-optimality of complex consonant clusters ([CC], [CCC], etc).

6 The NoCoda constraint is intended to show a preference for V-final syllables. A language whose constraint hierarchy contains a highly-ranked NoCoda constraint would prefer [.CV.] syllables to those of the form [.CVC.].

7 The purpose of the Align constraint is to ensure that syllables in the output remain in the same position as in the input.

8 The Ons(et) constraint represents a preference for C-initial syllables. A language whose constraint hierarchy contains a highly-ranked Onset constraint would prefer [.CV.] syllables to those of the form [.V(C).].

were underlyingly /(C)VCV/ or something similar, but for the sake of argument, we'll assume the inputs below.

Tableau 2: V syllables

	/VC1/	*Comp	NoCoda	Align	Ons	Max	Dep
a.	.C2C3VC1.	*!	*	**			**
b.	.C2VC1.		*!	*			*
c.	.C2V.			*!		*	*
d. ☞	.V.				*	*	

/VC1/			*Comp	NoCoda	Align	Ons	Max	Dep
.V.	~	.C2C3VC1.	W	W	W	L	L	W
.V.	~	.C2VC1.	e	W	W	L	L	W
.V.	~	.C2V.	e	e	W	L	e	W

At this point in history, all verb roots that are presently C-final ended in the high front vowel [i], and exhibited complete uniformity with respect to the past suffix, which at the time was /tari/:

Table 2: "C-final" past form verbs in Old Japanese

	Old form	Modern form	Gloss
a.	/kati+tari/	/kat+ta/	'win'+PAST
b.	/kari+tari/	/kar+ta/	'rent'+PAST
c.	/kaɸi+tari/	/kaw+ta/	'buy'+PAST
d.	/jobi+tari/	/job+ta/	'call'+PAST
e.	/sini+tari/	/sin+ta/	'die'+PAST
f.	/jomi+tari/	/jom+ta/	'read'+PAST
g.	/kasi+tari/	/kas+ta/	'lend'+PAST
h.	/kaki+tari/	/kak+ta/	'write'+PAST
i.	/kagi+tari/	/kag+ta/	'sniff'+PAST

Beginning sometime around the ninth century, massive borrowing of Chinese loanwords caused changes in the phonology of Japanese, likely to preserve as much as the original structure of the new words as possible. Originally allowing no codas whatsoever, Japanese phonology changed to accommodate codas containing nasals and place-linked

consonants, forming a sort of "proto"-CodaCond[9] (which I'll call ProdaCond). This new constraint would have displaced NoCoda in the hierarchy, creating a new ranking that would have looked something like the following:

Ranking 2: Post-Old Japanese

Max(Bor) » *Comp, ProdaCond, Align (L, PrWd, L, MWd) » Ons » Max, Dep » NoCoda

The constraint Max(Bor(rowed)) formalizes the segmental preservation of borrowed words, and motivates the allowance of certain types of codas as specified by ProdaCond.

Tableau 3: Interaction of Max (Bor) and ProdaCond

	/C1V1n+C2V2/	Max(Bor)	*Comp	ProdaCond	Align	Ons	Max	Dep	NoCoda
a.	.C1V1.C2V2.	*!					*		
b.	.C1V1.nC2V2.		*!		*				*
c.	.C1V1.nV3.C2V2.							*!	
d. ☞	.C1V2n.C2V2.								*

/C1V1n+C2V2/	Max(Bor)	*Comp	ProdaCond	Align	Ons	Max	Dep	NoCoda
.C1V2n.C2V2.～.C1V1.C2V2.	W	e	e	e	e	W	e	L
.C1V2n.C2V2.～.C1V1.nC2V2.	e	W	e	W	e	e	e	L
.C1V2n.C2V2.～.C1V1.nV3.C2V2.	e	e	e	e	e	e	W	L

This re-ranking played an important role in allowing the alternations seen in Modern Japanese past verbs, due largely to the interaction of the ranking with a group of language-wide changes that occurred around the same time called the *onbin* ('euphonic') changes, which included the following observed alterations to the language:

Onbin changes in Japanese:

i. Intervocalic /k/ deleted in non-initial syllables of verb and adjective roots.
ii. Intervocalic /ɸ/ changed to [w].
iii. /i/ deleted in verbs containing a /t/-initial suffix (as in past /tari/).
iv. [w] changed to [Ø] everywhere except before /a/.

9 The CodaCond constraint (Itô 1994) is intended to allow a language to specify the types of segments that may appear in a coda (the end of a syllable) in the output.

Assuming that the onbin changes above occurred in order listed above, they would have caused the Japanese past verbs to change into forms looking something like the ones in the following table:

Table 3: Post-Old Japanese "C-final" past form verbs

	Post-Old form	Modern form	Gloss
a.	/kat+tari/	/kat+ta/	'win'+PAST
b.	/kar+tari/	/kar+ta/	'rent'+PAST
c.	/kaw+tari/	/kaw+ta/	'buy'+PAST
d.	/job+tari/	/job+ta/	'call'+PAST
e.	/sin+tari/	/sin+ta/	'die'+PAST
f.	/jom+tari/	/jom+ta/	'read'+PAST
g.	/kas+tari/	/kas+ta/	'lend'+PAST
h.	/kai+tari/	/kak+ta/	'write'+PAST
i.	/kag+tari/	/kag+ta/	'sniff'+PAST

At this point, the past verbs looked much like they do in Modern Japanese. Many sources suggest that their surface forms looked something like this:

Table 4: Post-Old Japanese past form verbs

	Underlying	Surface	Gloss
a.	/kat+tari/	[kattari]	'win'+PAST
b.	/kar+tari/	[kattari]	'rent'+PAST
c.	/kaw+tari/	[kattari]	'buy'+PAST
d.	/job+tari/	[jondari]	'call'+PAST
e.	/sin+tari/	[ʃindari]	'die'+PAST
f.	/jom+tari/	[jondari]	'read'+PAST
g.	/kas+tari/	[kaʃitari]	'lend'+PAST
h.	/kai+tari/	[kaitari]	'write'+PAST
i.	/kag+tari/	[kaidari]	'sniff'+PAST

Totally faithful outputs of all forms except (a) and (h) would violate ProdaCond. It would appear that the following repair strategies are (were) at work to satisfy the constraint:

Repair strategies:

i. Gemination (in (b) and (c), and vacuously in (a))
ii. Nasalization (in (d))
iii. Epenthesis (in (e))

iv. "Undorsalization" with [voi] spreading in (i)
v. NPA (in (d), (e), and (f))
vi. Postnasal voicing (in (d), (e), (f), and (i))

Here the situation looks much the same as it did in §1. Note that the form /kai+tari/ seen in (h) eliminates the need to posit "undorsalization" for at least one root form. But there are still four repair strategies at work in the language. However, there are some other historical facts that need considering before attempting to form any further constraint re-ranking.

There is apparently evidence to suggest that intervocalic voiced obstruents were prenasalized in Old Japanese, causing nasalization of vowels that preceded them. In some cases, the voiced obstruents themselves changed to nasals. Remnants of this can still be seen in some dialects, and in the well-known [g]~[ŋ] alternation seen in the nominative case-marking morpheme /ga/, which generally occurs intervocalically.

If this is indeed the case, we can eliminate repairs (ii) and (iv) if we assume the following:

Assumptions that make this task much simpler:

i. Old Japanese /jobi+tari/ was actually /jõbi+tari/, later becoming /jõb+tari/, and then /jom+tari/.
ii. Old Japanese /kagi+tari/ was actually /kãgi+tari/, later becoming /kãg+tari/, and then /kaŋ+tari/.

Under these assumptions, the Post-Old Japanese forms would look like the following:

Table 5: Post-Old Japanese past form verbs (again)

	Underlying	Surface	Gloss
a.	/kat+tari/	[kattari]	'win'+PAST
b.	/kar+tari/	[kattari]	'rent'+PAST
c.	/kaw+tari/	[kattari]	'buy'+PAST
d.	/jom+tari/	[jondari]	'call'+PAST
e.	/sin+tari/	[ʃindari]	'die'+PAST
f.	/jom+tari/	[jondari]	'read'+PAST
g.	/kas+tari/	[kaʃitari]	'lend'+PAST
h.	/kai+tari/	[kaitari]	'write'+PAST
i.	/kaŋ+tari/	[kaidari]	'sniff'+PAST

The assumptions above simplify an analysis of these verbs because it reduces the changes in (d) to a simple matter of NPA and postnasal voicing. But the question still remains why the verb form /kaŋ+tari/ comes out as [kaidari].

The answer to this question may lie in the fact that, when syllable-final nasals were introduced into Old Japanese, they were often transcribed with the same symbol used to represent [i], as they did not yet have their own orthographical symbol. Apparently, enough speakers reinterpreted the spelling as being the correct pronunciation, that it caused a permanent change in the surface form. Assuming that NPA and postnasal voicing were present in the surface form, [kandari] was reinterpreted as [kaidari]. Or it could be that Japanese speakers simply perceived the syllable-final nasal sound as [i], and that misperception eventually made its way into the written language.

3. Towards a final constraint ranking

Assuming that the observations made about the historical changes are correct, we now have the following past verb forms:

Table 6: Post-Old Japanese past form verbs (yet again)

	Underlying	Surface	Gloss
a.	/kat+tari/	[kattari]	'win'+PAST
b.	/kar+tari/	[kattari]	'rent'+PAST
c.	/kaw+tari/	[kattari]	'buy'+PAST
d.	/jom+tari/	[jondari]	'call'+PAST
e.	/sin+tari/	[ʃindari]	'die'+PAST
f.	/jom+tari/	[jondari]	'read'+PAST
g.	/kas+tari/	[kaʃitari]	'lend'+PAST
h.	/kai+tari/	[kaitari]	'write'+PAST
i.	/kaŋ+tari/	[kaidari] ([kaŋdari])	'sniff'+PAST

We also have the following repair strategies to contend with:

Repair strategies:

i. Gemination (in (b) and (c), and vacuously in (a))

ii. Epenthesis (in (e))

iii. NPA (in (d), (e), and (f))

iv. Postnasal voicing (in (d), (e), (f), and (i))

The gemination seen in (b) and (c) is apparently motivated by the need to satisfy ProdaCond, resulting in faithfulness violations of Id (son, voi, lat[10], ant) in (b), and Id (son, cont, voi, r(oun)d[11]) in (a). This would seem to imply the following ranking:

Ranking 3: Gemination

ProdaCond » Id(son), Id(cont), Id(voi), Id(lat), Id(ant), Id(rd)

The epenthesis[12] seen in (e) might be seen as a preservation of [+strident] segments[13], implying the following ranking:

Ranking 4: Epenthesis

ProdaCond » Id(strid) » Dep

To account for NPA (a combination of "a nasal must assimilate to a following consonant" and Ident (nas)), we might assume the following ranking:

Ranking 5: NPA

NPA » Id(place)

Finally, to account for postnasal voicing, we can use *NÇ, which is similar to the constraint No-NT used in Itô and Mester (1999). Since obeying *NÇ would cause violations of Id(voice) in the onset of the suffix /tari/ (the onset of which is not otherwise changed), we should probably assume that *NÇ is ranked above IdOns.

10 The alveolar liquid /r/ in Japanese is actually a flap, which many consider to be [+lateral].

11 The model of distinctive features (see Uffmann) in this analysis classifies /w/ as [+round] instead of [+labial], as seen in other models, since the lips don't actually come in full contact during the pronunciation of /w/.

12 It is worth mentioning here that the epenthetic vowel in Japanese is ordinarily /u/. However, front vowels, particularly the high front vowel /i/, occur often in verb roots and verb suffixes. In fact, the only vowels that can appear in V-final verb roots are /i/and /e/, so there might be good reason to believe that the epenthetic vowel for Japanese verbs is /i/ (or at least a front vowel).

13 Frankly, I can't see the real phonetic motivation for this, but [+strident] is, as far as I can tell, the only feature that distinguishes /s/, which does not delete, from /r/ and /w/, which assimilate to a geminate.

Ranking 6: Postnasal voicing

*NC̬ » IdOns

Combining all the constraints in rankings 3-6 with the ranking for Post-Old Japanese yields the following ranking (Max(Bor) has been removed for simplicity):

Ranking 7: Post-Old Japanese

*Comp, ProdaCond, Align(L, PrWd, L, MWd), Npa, *NC̬ » Ons, Id(strid) » Max, Dep » IdOns » Id(son), Id(cont), Id(voi), Id(lat), Id(ant), Id(rd) » NoCoda

To simplify the following tableaux, I'll simplify the highest ranking constraints into a single constraint, HighRank, and all of the Id constraints (except IdOns and Id(strid)) into a single constraint, IdOther:

Ranking 7': Post-Old Japanese

HighRank » Ons, IdOns, Id(strid) » Max, Dep » IdOns » IdOther » NoCoda

The following tableaux show how the ranking 7' accounts for the surface forms of the verbs in table 6, specifically, why one repair is used over another for a particular form.

Tableaux 4 and 5 illustrate how gemination is chosen over NPA or epenthesis:

Tableau 4: /kar+tari/

	/kar+tari/	HighRank	Ons	Id(strid)	Max	Dep	IdOns	IdOther	NoCoda
a.	kartari	*!							*
b.	kandari						*!	*	
c.	karitari					!*			
d.	☞ kattari							****	

/kar+tari/	HighRank	Ons	Id(strid)	Max	Dep	IdOns	IdOther	NoCoda
kattari~kartari	W	e	e	e	e	e	L	W
kattari~kandari	e	e	e	e	e	W	W	e
kattari~karitari	e	e	e	e	W	e	L	e

Tableau 5: /kaw+tari/

	/kaw+tari/	HighRank	Ons	Id(strid)	Max	Dep	IdOns	IdOther	NoCoda
a.	kawtari	*!							*
b.	kandari						*!	******	
c.	kawitari					!*			
d.	☞ kattari							Lots	

/kaw+tari/	HighRank	Ons	Id(strid)	Max	Dep	IdOns	IdOther	NoCoda
kattari～kawtari	W	e	e	e	e	e	L	W
kattari～kandari	e	e	e	e	e	W	W	e
kattari～kawitari	e	e	e	e	W	e	L	e

Note: Candidate (c) would be pronounced [kaitari], since /wi/ became /i/.

Tableaux 6-8 illustrate how NPA is chosen over gemination or epenthesis (note: all of the (d) candidates violate the NPA constraint):

Tableau 6: /jom+tari/

	/jom+tari/	HighRank	Ons	Id(strid)	Max	Dep	IdOns	IdOther	NoCoda
a.	jomtari	*!							*
b.	☞ jondari						*	*	
c.	jonitari					!*			
d.	jottari	*!						Lots	

/jom+tari/	HighRank	Ons	Id(strid)	Max	Dep	IdOns	IdOther	NoCoda
jondari～jomtari	W	e	e	e	e	L	e	W
jondari～jonitari	e	e	e	e	W	L	W	e
jondari～jottari	W	e	e	e	e	e	W	e

Tableau 7: /sin+tari/

	/sin+tari/	HighRank	Ons	Id(strid)	Max	Dep	IdOns	IdOther	NoCoda
a.	sintari	*!							*
b.	☞ sindari						*	*	
c.	sinitari					!*			
d.	sittari	*!						Lots	

/sin+tari/	HighRank	Ons	Id(strid)	Max	Dep	IdOns	IdOther	NoCoda
sindari～sintari	W	e	e	e	e	L	e	W
sindari～sinitari	e	e	e	e	W	L	W	e
sindari～sittari	W	e	e	e	e	e	W	e

Tableau 8: /kaŋ+tari/

	/kaŋ+tari/	HighRank	Ons	Id(strid)	Max	Dep	IdOns	IdOther	NoCoda
a.	kaɲtari	*!							*
b.	☞ kandari						*	*	
c.	kaɲitari					!*			
d.	kattari	*!						Lots	

/kaŋ+tari/	HighRank	Ons	Id(strid)	Max	Dep	IdOns	IdOther	NoCoda
kandari～kaŋtari	W	e	e	e	e	L	e	W
kandari～kaŋitari	e	e	e	e	W	L	W	e
kandari～kattari	W	e	e	e	e	e	W	e

Note: [kandari] became [kaidari] as a result of spelling reinterpretation.

Finally, tableau 9 shows how epenthesis is chosen over NPA and gemination:

Tableau 9: /kas+tari/

	/kas+tari/	HighRank	Ons	Id(strid)	Max	Dep	IdOns	IdOther	NoCoda
a.	kastari	*!							*
b.	kandari	*!		*			*	*	
c.	☞ kasitari					*			
d.	kattari			*!				Lots	

/kas+tari/	HighRank	Ons	Id(strid)	Max	Dep	IdOns	IdOther	NoCoda
kasitari～kastari	W	e	e	e	e	e	e	W
kasitari～kandari	W	e	e	e	e	W	W	W
kasitari～kattari	e	e	W	e	L	e	W	e

As a last step in this process (although the exact time of the change isn't explicitly mentioned in any of the literature I've seen), the final /ri/ dropped from the past suffix, leaving us with the surface forms of past verbs seen in Modern Japanese.

4. Concluding Remarks

Most of the analyses of Japanese verb morphology I have come across, generative or otherwise, are based solely on the modern surface forms of the verbs. The analysis presented here hopefully illustrates the importance of accounting for diachronic changes in forming a synchronic phonological analysis of a language. I should note, however, that the present analysis might not apply to the other verb forms in Japanese. It seems that many of the historical changes that the analysis is based on affected only the past verbs, so it's entirely possible that other changes applied in the other verb forms, requiring separate rankings. I think this would be an interesting topic to pursue at a future time.

5. Appendix: Optimality Theory

In 1993, linguists Alan Prince and Paul Smolensky released a paper entitled "Optimality Theory: Constraint Interaction in Generative Grammar", in which they proposed that observed phonological phenomena did not arise from a series of phonological rules, as was the standard thinking at the time, but rather from an input-output relation governed by conflicting constraints on phonological "markedness" and "faithfulness". They described markedness constraints as "conditions on the well-formedness of the output", and faithfulness constraints as "conditions asking for the exact preservation of the input in the output along various dimensions". The influence of the constraints on a set of phonological inputs leads to a single, "optimal" output, hence the name "Optimality Theory" (hereafter, "OT").

Basic components of OT

i. GEN
ii. CON
iii. EVAL

The theory has three basic components: GEN, CON, and EVAL. The GEN component generates a set of candidate outputs from an infinite set of inputs. The CON component is a set of universal markedness and faithfulness constraints. Different languages are represented by different rankings of the various constraints in the set, as different rankings will lead to a different range of possible outputs. Finally, the EVAL component judges each candidate output produced by GEN based on how many constraints it satisfies. A candidate output is deemed to be the optimal output if it satisfies more constraints than its "rival" candidate outputs.

Common constraints

i. Max (don't delete any phonological segments)
ii. Dep (don't add any phonological segments)
iii. Ident(f) (don't change any phonological features)

Many of the constraints used in OT are based on three prototypical ones: Max, Dep, and Ident(f). Prince and John McCarthy (1995) define the general schema of Max as "Every segment of S_1 has a correspondent in S_2", or in other words, whatever phonological segments exist in the input must also exist in the output. Constraints derived from Max are meant to prevent phonological deletion. Next is Dep, which stands for "don't epenthesize", and is basically the opposite of Max Prince and McCarthy define Dep as "Every segment of S_2 has a correspondent in S_1", which essentially means that if a segment is present in the output, it must have also been present in the input. Dep constraints are meant to prevent phonological addition. Finally, Ident(f), in which "Ident" stands for "Identity" or "Identical", means that a specified phonological feature ("f") of a given output segment should be identical to its correspondent feature in the input. Specifying phonological features for Ident is optional.

Ranking of constraints

Max » Dep » Ident

Different phonological systems are represented as hierarchies of constraints, and they are notated using the convention shown above. Constraints are listed from left-to-right, from highest to lowest rank, with each rank separated by double angled brackets (»). The hierarchy above is what is known as a "strict" hierarchy, meaning each tier of the hierarchy contains only one constraint. However, it is possible (and quite common) for multiple constraints to share the same tier.

Evaluation of outputs

	/play/ + z	Max	Dep	Ident
a. ☞	playz			
b.	plays			*!
c.	playɪz		*!	
d.	play	*!		

The above is an example of a typical "tableau" (French for "table") seen in many OT-based analyses. The top row, from left to right, shows the input and the constraints Max, Dep, and Ident. Candidate outputs, a sufficient subset of which is chosen the infinite set

produced by Gen, are listed under the input. Each constraint violation is marked with asterisk (*), and an exclamation point (!) represents a "crucial" (also called "fatal") violation, or in other words a violation that eliminates a candidate from being an actual output. Grayed-out cells represent areas of the table that are irrelevant to the overall outcome.

This particular tableau shows the constraint ranking responsible for the observed phonological form of the second person singular simple present verb "play". The optimal output is [playz], because it violates the lowest number of high-ranked constraints (in fact, it violates none). The candidate [plays] is ruled out because it violates Ident (output [s] differs in voicing from input /z/); candidate [playiz] loses because it violates Dep (due to the presence of the segment [ɪ] in the output); and candidate [play] is eliminated for a violation of Max (the output contains one less segment than the input).

Comparative tableau

/play/ + z			Max	Dep	Ident
playz	～	plays	e	e	W
playz	～	playiz	e	W	e
playz	～	play	W	e	e

Output evaluations can also be represented by another form of tableau called a "comparative tableau". This form of tableau shows evaluation as a series of bouts between competing candidates. Each bout is represented as A ～ B, with A representing the winning candidate (i.e. the observed output), and B representing the losing candidate. A "W" shows that a constraint prefers the winning candidate, and an "L" (not shown above) shows that a constraint prefers the losing candidate. An "e" represents a "draw" (or "even") match. Comparative tableaux are perhaps more intuitive than traditional (often called "flyspeck") tableaux because they more directly represent the "competition" between candidate outputs. The tableau above shows that [playz] is the most optimal output because it wins each bout.

I have used both types of tableau in this paper in an effort to more clearly show the process of candidate evaluation.

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