Class 1
Introduction to Optimality Theory in Phonology

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Rules and Constraints

(Phonological) Rules

- Generalizations in phonology have traditionally been expressed in terms of **phonological rules**:

(1) /X/ → [Y] / A_B

"(The segment/feature/...) X becomes Y in the context of a preceding A and a following B"

Rules and Constraints

(Phonological) Rules

- Rules have also been used in morphology and syntax:

(2) Allomorphy ("Vocabulary Insertion") in morphology, e.g. English plural:
PL ⇔ /-ən/ / _{OX,...}
PL ⇔ /-Ø/ / _{MOOSE,...}
PL ⇔ /-z/ / elsewhere

(3) Phrase Structure Rules or Transformations in syntax:

a. VP rule: *VP* → *V (NP)*

b. Passive rule:
Subject V Object → *Object* BE *V*-PASS *by Subject*

Rules and Constraints

(Phonological) Rules

- As an example of a phonological rule, consider the following data from German (Brockhaus 1995:4):

(4) Alternations in German

a.	*bunte*	[bʊn**t**-ə]	'colorful-NOM.FEM.SG.'
	bunt	[bʊn**t**]	'colorful.NOM.MASC.SG.'
b.	*Bunde*	[bʊn**d**-ə]	'league-DAT.SG.'
	Bund	[bʊn**t**]	'league.NOM.SG.'

▷ *What's going on here?*

Rules and Constraints

(Phonological) Rules

- There's an underlying /d/ (voiced alveolar stop) in 'league', which becomes a [t] (voiceless alveolar stop) in the nominative singular, when it is *word-final*.
  → If we looked at more words, we'd see that this is fully general, applying to all obstruents (stops, fricatives, affricates) in word-final position.

- So, we can write the rule in (5): ([−sonorant] = *obstruent*)

(5) **Final obstruent devoicing in German**

a. maximal: /−sonorant, +voice/ → [−sonorant, −voice] / _#
b. minimal: /−sonorant/ → [−voice] / _#

Rules and Constraints

(Phonological) Rules

- In phonology at least, rules can be phrased in an alternative, more holistic way:

(6)

/AXB/	→	[AYB]
↑		↑
Structural Description		*Structural Change*

- For the German final devoicing rule:

(7) [−son, +voice]# → [−son, −voice]#

Rules and Constraints

Constraints

- Now consider a different way of looking at the problem:

(8) a. *Having a word-final voiced obstruent is bad.*
[= structural description of the rule]

b. *Changing a voiced obstruent to a voiceless one is ok.*
[≈ structural change of the rule]

- These concepts can be translated into **constraints**.
- Let's start with the first one:

(9) **No Final Voiced Obstruents ([−son, +voice]#)**:
This constraint is *violated* when there is a voiced obstruent in word-final position in a surface form. [***D#**] [= (8a)]

Rules and Constraints

Constraints

- When we compare two possible surface forms (forget, for the moment, the underlying forms), this constraint will **prefer** a surface form with a final *voiceless* obstruent (10a) over a surface form with a *voiced* obstruent (10b).

(10)

		*D#
a.	bunt	
b.	bund	*

" * " indicates that the form in that row violates the constraint in that column

Rules and Constraints

Constraints

- We call this kind of a constraint a **markednesss** constraint, because it penalizes the presence of a "marked" structure in surface forms.
  - From some perspectives at least (e.g. Hayes, Kirchner, & Steriade 2004), marked structures are those which are phonetically problematic, i.e. difficult to produce or perceive.

  → It is particularly difficult to maintain voicing in a stop in word-final position because of the way that a stop closure affects the aerodynamics of the vocal tract (Westbury & Keating 1986).

Rules and Constraints

Constraints

- If the grammar only consisted of markedness constraints, we'd expect that no language would ever have any marked structures. This is obviously not the case.
- Compare English, which *does* have final voiced obstruents:

(11) a. *want* [want**t**]
b. *wand* [wan**d**]

Rules and Constraints

Constraints

- Within a constraint-based approach, we can capture this by adding in a second, counter-balancing type of constraint: **faithfulness** (Prince & Smolensky [1993] 2004, McCarthy & Prince 1995, 1999).
  - Faithfulness constraints incur violations for particular types of *structural changes* (differences between input and output).

- The faithfulness constraint that regulates *feature change* is called IDENT:

(12) **Ident[voice]:** This constraint is violated if a segment's voicing changes from the input (underlying form) to the output (surface form).

Rules and Constraints

Constraints

- Consider again (8b): *changing a voiced obstruent to a voiceless one is ok.*
  - It's only "ok", not perfect, because this change does violate IDENT[voice].

- If we're looking at an underlying form with a voiced stop, /bund/, changing the voicing value to [bunt] will incur a violation of IDENT[voice]:

(13)

/bund/		IDENT[voice]
a.	bunt	*
b.	bund	

Rules and Constraints

Constraints

- Now compare the way that the two constraints apply violations (we'll use UR /bund/ for both):

(14)

/bund/		*D#
a.	bunt	
b.	bund	*

/bund/		IDENT[voice]
a.	bunt	*
b.	bund	

- The two constraints assign their violations to different surface forms.
- We know that the real surface form that we're trying to derive is [bunt].

▷ *How can we use these constraints to derive the right form?*

Optimality Theory

Overview

⇒ **Optimality Theory** [OT] (Prince & Smolensky [1993] 2004) is a framework that derives surface forms through *constraint interaction/competition* in the form of **constraint ranking**.

Optimality Theory

Overview

⋆ Optimality Theory is a theory of *computation*, not a theory of phonology, per se.

- Therefore, it can be, and has been, applied to domains outside of phonology.

⋆ (Standard) Optimality Theory is not the only way to use constraints to derive (phonological) forms.

- There are many frameworks which derive from standard OT but adjust various aspects of its basic architecture:
  - **Stratal OT** (Kiparsky 2000, 2015)
  - **Harmonic Serialism** (McCarthy 2000, 2010)
  - **Harmonic Grammar** (Legendre, Miyata, & Smolensky 1990, Smolensky & Legendre 2006)
  - **Cophonology Theory** (Inkelas & Zoll 2007)

Optimality Theory

Overview

- OT has three core components:

(15) **Components of OT**

a. **GEN** ("generator"): the grammar furnishes all possible surface forms ("candidate outputs").

b. **CON** ("constraints"): the grammar furnishes a *language-specific* constraint ranking.

c. **EVAL** ("evaluator"): the grammar applies constraint violations to all candidate outputs (*relative to a specified input*), and selects the candidate with the best violation profile.

Optimality Theory

Overview

- In standard OT, EVAL works as follows:

(16) **Eval Procedure**

i. Look at the highest ranked constraint.
ii. Identify all the candidates that have the lowest number of violations (usually this is 0, but it may be > 0).
iii. Eliminate all other outputs.
iv. Look at the next highest ranked constraint.
v. Repeat until you have eliminated all but one candidate. That candidate is selected as the winner.

Optimality Theory

Overview

- An OT derivation is usually represented in a "**tableau**", like the one in (18). [I'll explain the tableau itself more below.] The notation does a lot of work here, so it's important to internalize the details:

(17) **Tableau Notation**

a. The input to the derivation is given in the top left box.
b. Each candidate is given its own row.
c. Each constraint is given its own column. A solid vertical line between constraint columns indicates that the constraint on the left is ranked higher than the constraint on the right.

(18)

/bund/	*D#	IDENT[voice]
a. ☞ bunt		*
b. bund	*!	

Optimality Theory

Overview

(17) **Tableau Notation (cont.)**

d. In each box, " * " indicates that that constraint assigns a violation to that candidate. A given candidate can violate a given constraint multiple times.

e. " ! " indicates a **crucial** violation, i.e. a violation that eliminates a candidate.

f. " ☞ " indicates the candidate that the constraint ranking selects as the winner. (If you've done your analysis right, this will be the actual output form.)

(18)

/bund/	*D#	IDENT[voice]
a. ☞ bunt		*
b. bund	*!	

Optimality Theory

Deriving German devoicing in OT

- With all that said, the way we derive the German pattern is by **ranking** *D# *above* IDENT[voice].

(19) *D# ≫ IDENT[voice]

" ≫ " means "ranks above" / "dominates"

- Using this ranking, we can integrate that two tables in (14) into a single tableau that generates the derivation /bund/ → [bunt]:

(20)

/bund/	*D#	IDENT[voice]
a. ☞ bunt		*
b. bund	*!	

Optimality Theory

Deriving German devoicing in OT

- The key to putting together a good OT analysis is that your ranking needs to work for the whole set of forms, not just the ones where the process applies.

▷ *Is this the case for this ranking?*

Optimality Theory

Deriving German devoicing in OT

- Yes it does!

(21) **/T/, no affix**: /bunt/ → [bunt]

/bun**t**/	*D#	IDENT[voice]
a. ☞ bunt		
b. bund	*!	*

(22) **/D/, no affix**: /bund/ → [bunt]

/bun**d**/	*D#	IDENT[voice]
a. ☞ bunt		*
b. bund	*!	

(23) **/T/, affix**: /bunt-ə/ → [buntə]

/bun**t**-ə/	*D#	IDENT[voice]
a. ☞ bunt-ə		
b. bund-ə		*!

(24) **/D/, affix**: /bund-ə/ → [bundə]

/bun**d**-ə/	*D#	IDENT[voice]
a. bunt-ə		*!
b. ☞ bund-ə		

Optimality Theory

Deriving German devoicing in OT

- There's one more step that has to go into an OT analysis: making sure you select *the right repair* for your markedness constraint.

- Feature change is not the only possible change (= repair) that you can apply to the input (see McCarthy & Prince 1995).
- The two main other ones are **deletion** and **epenthesis/insertion**. These are governed by the constraints MAX and DEP respectively:

(25) a. **Max:** Assign a violation for each segment in the *input* which is not present in the *output*. [= *Don't delete!*]

b. **Dep:** Assign a violation for each segment in the *output* which is not present in the *input*. [= *Don't insert!*]

Optimality Theory

Deriving German devoicing in OT

- When there are multiple potential changes that could satisfy a markedness constraint, the optimal output is the candidate that violates the *lowest-ranked faithfulness constraint*:

(26) /bund/ → [bunt]

/bun**d**/		*D#	MAX	DEP	IDENT[voice]
a.	bund	*!			
b.	bun		*!		
c.	bundə			*!	
d. ☞	bunt				*

Optimality Theory

Some more properties of OT

- Using OT, we expect differences between languages to be the by-product of differences in rankings among the same constraints.

  → Therefore, OT *can* be viewed as a theory of *typology*.

- This is true when we look back at English. If we swap the ranking of our two constraints, we derive the permission of word-final voiced obstruents:

(27)

/want**t**/	IDENT[voice]	*D#
a. ☞ want		
b. wand	*!	*

(28)

/wan**d**/	IDENT[voice]	*D#
a. want	*!	
b. ☞ wand		*

Optimality Theory

Some more properties of OT

- In general, using OT, we can understand the distinction between *contrast* and *neutralization* in terms of the relative ranking of markedness [$\mathbb{M}$] (e.g. *D#) and faithfulness [$\mathbb{F}$] (e.g. IDENT[voice]).

(29) a. **Contrast** = $\mathbb{F} \gg \mathbb{M}$

IDENT[voice] $\gg$ *D#

English has a final voicing contrast ↩

b. **Neutralization** = $\mathbb{M} \gg \mathbb{F}$

*D# $\gg$ IDENT[voice]

German neutralizes final voicing ↩

- Relatedly, a *phonological process* is defined by an $\mathbb{M} \gg \mathbb{F}$ ranking.
  - In other words, changing the input can only be triggered by the need to repair a marked structure.

Conspiracies: Lardil word minimality

⋆ **What do we gain by using constraints instead of rules?**

- One thing is that we can identify the *motivation* for processes/generalizations, i.e. markedness constraints, which are reified, manipulable entities of the grammar.

→ Another (related) thing is that it captures **conspiracies**.

- Let's look at a set of interactions in Lardil (Tangkic, Pama-Nyungan; Australia).
  - Lardil phonology was first described by Hale (1973). I'll be taking the data from Klokeid (1976) and Staroverov (2014).
  - I follow Staroverov's (2014) IPA-based transcription.

Conspiracies: Lardil word minimality

Apocope

- Lardil has a process that deletes word-final vowels ("apocope"):

(30) Apocope in Lardil (Staroverov 2014:429)

	Gloss	UR	NOM /-Ø/	ACC /-(i)n/
a.	'oyster sp.'	/jilijili**i**/	[jilijil]	[jilijili**i**-n]
b.	'rainbow'	/majar**i**/	[majar]	[majar**i**-n]
c.	'bush mango'	/wiwal**a**/	[wiwal]	[wiwal**a**-n]

- In the nominative, where no overt suffix follows and the root-final vowel would be word-final, that vowel deletes.
- We see evidence of that underlying vowel in the accusative (and elsewhere), where it is protected from word-final position by a suffix.

Conspiracies: Lardil word minimality

Apocope

- We can capture this generalization with the following rule:

(31) **Lardil apocope rule**
V → Ø/ _# (or V# → Ø#)

- Alternatively, we could capture the generalization through constraint ranking:

(32) **Lardil apocope ranking**
*V# ≫ Max
("*It's better to delete a vowel than to have a word-final vowel.*")

Conspiracies: Lardil word minimality

Apocope

- We can illustrate how this ranking derives apocope in the tableau in (33).
  - The fact that vowel deletion is employed to satisfy *V#, rather than, e.g., consonant epenthesis, can be derived by ranking Dep over Max.

(33) **Lardil apocope**

/wiwala/		Dep	*V#	Max
a. wiwala			*!	
b. ☞ wiwal				*
c. wiwalat		*!		

Conspiracies: Lardil word minimality

Apocope

- In the general case, both of these analyses work fine. However, the apocope process has a systematic set of exceptions.
  → If the root is only **two syllables** long, apocope *fails to apply*.

(34) No apocope in disyllabic roots (Staroverov 2014:441)

	Gloss	UR	NOM /-Ø/		
a.	'white pigeon'	/pækæ/	[pækæ]	(*[pæk])	
b.	'shell sp.'	/jilæ/	[jilæ]	(*[jil])	
c.	'inside, interior'	/wiɻæ/	[wiɻæ]	(*[wiɻ])	(cf. ACC wiɻæ-n)
d.	'dorsal fin of fish'	/mupa/	[mupa]	(*[mup])	(cf. FUT.ACC mupa-ɻ)
e.	'bird sp.'	/mica/	[mica]	(*[mic])	
f.	'sea water; grog'	/mæla/	[mæla]	(*[mæl])	(cf. ACC mæla-n)

Conspiracies: Lardil word minimality

Apocope

- We could hardwire this into the apocope rule by requiring at least two syllables before the final vowel, but this lacks explanatory value:

(35) **Lardil apocope rule (revised...to be rejected)**
$V \rightarrow \emptyset / \ VC_0VC_0\_\#$

- Alternatively, we could account for this in terms of *blocking* via constraints in OT:

(36) **Lardil apocope ranking revised**
$\mathbb{C} \gg *V\# \gg \textsc{Max}$
(“*It’s better to have a word-final vowel than to violate* $\mathbb{C}$.”)

- If we can find a constraint $\mathbb{C}$ which would be violated by apocope only when it applies to a two syllable word, then we can construct an analysis that does have explanatory value.

Conspiracies: Lardil word minimality

Apocope

- Lots of languages require words to be minimally disyllabic.
  - This usually has something to do with stress and/or prosodic structure (we'll talk more about this in the next units).
- We can implement this with a constraint like "MinWord" (37):

(37) **MinWord**: Assign a violation for any word which is less than two syllables. (Alternatively: *#σ#)

Conspiracies: Lardil word minimality

Apocope

- If MinWord ≫ *V#, this will *block* vowel deletion just in case apocope would create a word with less than two syllables (38).
- This constraint will have no effect with longer roots, where vowel deletion won't create a sub-minimal word (39).

(38) **Apocope is blocked in 2 syll roots**

/mupa/		MinWord	Dep	*V#	Max
a. ☞ mupa				*	
b. mup		*!			*
c. mupat			*!		

This is a clear **simultaneous *inhibitory*** interaction

(39) **Apocope occurs in 3+ syll roots** [= (33)]

/wiwala/		MinWord	Dep	*V#	Max
a. wiwala				*!	
b. ☞ wiwal					*
c. wiwalat			*!		

Conspiracies: Lardil word minimality

Apocope

- We could still have done this with the constraint-based equivalent of the brute force rule in (35) by changing the markedness constraint to match the expanded structural description in (35): *$VC_0VC_0V\#$

(40) **Apocope not motivated in 2 syll roots**

/mupa/	DEP	*$VC_0VC_0V\#$	MAX
a. ☞ mupa			
b. mup			*!
c. mupat	*!		

(41) **Apocope motivated in 3+ syll roots**

/wiwala/	DEP	*$VC_0VC_0V\#$	MAX
a. wiwala		*!	
b. ☞ wiwal			*
c. wiwalat	*!		

Conspiracies: Lardil word minimality

Augmentation

- However, once we bring in another fact, we'll see that we really do need the MinWord analysis.

- Lardil has CVC roots. In suffix-less forms like the nominative, these roots surface with an *epenthetic* word-final vowel [a].

(42) Augmentation in CVC roots (Klokeid 1976:54)

	Gloss	UR	NOM /-Ø/	ACC /-(i)n/
a.	'thigh'	/tær/	[tær**a**]	[tær-in]
b.	'fish'	/jak/	[jak**a**]	[jak-in]

Conspiracies: Lardil word minimality

Augmentation

- This is not a general process of epenthesis after a final consonant, since longer consonant-final roots don't undergo it:

(43) No augmentation in longer C-final roots (Klokeid 1976:38)

	Gloss	UR	NOM /-Ø/	ACC /-(i)n/
a.	'red rock cod'	/jupuɾ/	[jupuɾ]	[jupuɾ-in]
b.	'spear'	/mijaɻ/	[mijaɻ]	[mijaɻ-in]
c.	'dugong'	/kæntapal/	[kæntapal]	[kæntapal-in]
d.	'horse'	/jaɾaman/	[jaɾaman]	[jaɾaman-in]

Conspiracies: Lardil word minimality

Augmentation

- We could capture this pattern in terms of rules, but again, this would lack explanatory value:

(44) **Lardil augmentation**
$\emptyset \rightarrow$ a / $\#C_0VC_0\_\#$

- On the other hand, we already have a constraint that will motivate augmentation in exactly this context: MinWord.

Conspiracies: Lardil word minimality

Augmentation

- As long as MinWord ≫ Dep (consistent w/ previous rankings), we generate epenthesis as a repair for sub-minimality in CVC roots (45).
- Since longer roots aren't sub-minimal, they don't need to be repaired (46).

(45) **Augmentation occurs in CVC roots**

/jak/		MinWord	Dep	*V#	Max
a.	jak	*!			
b.	ja	*!		*	*
c. ☞	jaka		*	*	
d.	jakat		**!		

(46) **Augmentation not motivated in longer C-final roots**

/mijaɻ/		MinWord	Dep	*V#	Max
a. ☞	mijaɻ				
b.	mija			*!	*
c.	mijaɻa		*!	*	
d.	mijaɻat		*!*		

Conspiracies: Lardil word minimality

Conspiracies motivate constraints

- Consider again the phonological rules we would need to capture the facts:

(47) a. $V \rightarrow \emptyset / \ VC_0VC_0\_\#$
b. $\emptyset \rightarrow a \ / \ \#C_0VC_0\_\#$

- These rules do the complete opposite thing:
  - one deletes a vowel word-finally
  - the other inserts a vowel word-finally
- They also both require a highly specific, seemingly unrelated context.

Conspiracies: Lardil word minimality

Conspiracies motivate constraints

- But in reality, both processes seem to respond to the same motivation: *word minimality*.
  - In other words, these rules ***conspire*** to make/keep all surface forms at least two syllables long.

→ We call this a **conspiracy** (Kisseberth 1970).

- Conspiracies are fairly common language-internally (though it's so common place that it's not always noted as such).
- And if we think about conspiracies as being *multiple repairs for the same underlying problem*, we see them everywhere when we look cross-linguistically (including in domains outside of phonology...).

Conspiracies: Lardil word minimality

Conspiracies motivate constraints

- Rule-based phonology has no obvious way to encode conspiracies in the grammar; they would have to be entirely epiphenomenal.

⋆ Therefore, to the extent that we want to encode conspiracies in the grammar itself, we need a **constraint-based** theory of phonology.

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