

## **Today's topics:**

- **Factorial typology**
- **Segmental distribution**
- **Implications of typological gaps**

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*Background preparation:*

- McCarthy (2008), sec 2.8 (from last time)

# 0. Course information and announcements

- Analysis assignment #2 due Tu Mar 26
- May be written up individually or in pairs
  - Discussion collaboration (with anyone in our class) is welcome and encouraged
  - Any clarification questions?

# 0. Today's key points

- Review: Predictable patterns and ROTB
  - Complementary distribution
- Factorial typology
  - Determining the typological predictions of a constraint set
  - Implications for our analysis of complementary distribution
- In general: Patterns of segmental distribution

# 1. Review: Predictable patterns and ROTB

From a constraint-based perspective

- **Predictable** info: **enforced by the grammar**
  - This means that predictable information is enforced by the **constraints** as they are **ranked** in a particular language

# 1. Review: Predictable patterns and ROTB

- **Richness of the Base (ROTB):** There are no language-particular restrictions on input forms
  - If something is a possible input in one language (such as /CVC/), it is a **possible input in all languages**
  - **Hypothetical inputs**, that don't correspond to actual URs of the language, are sometimes needed in order to test the grammar's ability to rule out ungrammatical forms
- *Last time:* What are the implications of ROTB for patterns of **complementary distribution**?

## 2. Review: ROTB & complementary distribution

- What kind of **descriptive generalization** can we make about the Spanish data set in McCarthy (2008), sec 2.8, ex (30)?
  - Voiced fricatives appear after [+approx]
  - Voiced stops appear elsewhere
- Can we propose constraints analogous to those for Yoruba, Madurese nasalization patterns (p 91)?
  - What ranking do we need for Spanish?
  - **Today's focus:**  
What are the **cross-linguistic (typological) consequences** of proposing these constraints?

## 2. Review: ROTB & complementary distribution

- **F** constraint related to the **difference** between allophones
- **M** constraint forcing the **context-specific** allophone
- **M** constraint forcing the **elsewhere** allophone

## 2. Review: ROTB & complementary distribution

- **F** constraint related to the **difference** between allophones

**IDENT[±cont]**

- **M** constraint forcing the **context-specific** allophone

**\*VD** 'assign one \* for every **sequence** of segments [+approx] [-son, -cont, +voi]'

- **M** constraint forcing the **elsewhere** allophone

**\*VOIFRIC** 'assign one \* for every **segment** that is [-son, +cont, +voi]'



## 2. Review: ROTB & complementary distribution

- How are these constraints ranked for Spanish?  
(What rankings among them can we **prove**?)

<b>/aba/</b>	*VD	*VoiFRIC	IDENT[±cont]
(a) [aba]	* W	L	L
→ (b) <b>[aβa]</b>		*	*

<b>/βa/</b>	*VD	*VoiFRIC	IDENT[±cont]
(a) [βa]		* W	L
→ (b) <b>[ba]</b>			*

- Note the key role of **ROTB** here

## 2. Review: ROTB & complementary distribution

- Review... what is the UR for [b]~[β] in Spanish?
  - Could it be [b]?
  - Could it be [β]?
  - Could it be abstract/underspecified?
  - What information **must** this UR contain?

### 3. Factorial typology

- So far, we have focused on how to analyze the phonology of a single language using OT
- But: The OT analysis of one language **automatically makes predictions** about cross-linguistic phonological patterns (much more so than in rule-based phonology)
  - Why?

### 3. Factorial typology

- The OT framework includes the proposal that **constraints are universal**
  - Any constraint we introduce for the analysis of *one* language is automatically predicted to be included in the constraint set of *every* language
- Thus: The OT analysis of one language **makes predictions** about the range of possible cross-linguistic patterns

### 3. Factorial typology

- We can examine the **factorial typology** of a set of constraints to **determine its predictions**  
(Prince & Smolensky 1993)
  - What is the *factorial typology* of a constraint set?
  - Why is it called that?

### 3. Factorial typology

- We can examine the **factorial typology** of a set of constraints to **determine its predictions**  
(Prince & Smolensky 1993)
  - The factorial typology of a set of constraints is the set of **all rankings** of those constraints
  - If we have  $n$  constraints, there are  $n!$  (“ $n$  factorial”) ways to rank them
$$n! = (n) * (n-1) * (n-2) * \dots * 1$$
  - Question: To what extent can/should factorial typology **match** the typology of observed languages?  
( → see below)

### 3. Factorial typology

- Once we know the different possible rankings of a set of constraints, we can look at **what kinds of outputs will win** under each of the rankings

Reminder: This is a different way of using a tableau

- Until now, we have known the **input** and the **output**, and our goal was to determine what **ranking** was necessary to make that output win
- Now, we know the **ranking** and the **input**, and we want to know what **output** will be the winner

## 4. Factorial typology of segmental distribution

- What is the **factorial typology** of these constraints?

IDENT[±CONT]

\*VD            'assign one \* for ... [+approx] [-son, -cont, +voi]'

\*VOIFRIC      'assign one \* for ... [-son, +cont, +voi]'

- How many **possible rankings** are there?

What are they?

- Given /ba/, /βa/, /aba/, and /aβa/, what wins under each of the rankings?

- What **distribution patterns** are predicted for the segments [b] and [β] under each ranking?



## 4. Factorial typology of segmental distribution

- How many rankings are there for these three constraints? **\*VD**, **\*VoiFRIC**, **IDENT[±cont]**

3! = 6 rankings

1	*VD	»	*VoiFRIC	»	IDENT[±cont]	(= Spanish)
2	IDENT[±cont]	»	*VoiFRIC	»	*VD	
3	IDENT[±cont]	»	*VD	»	*VoiFRIC	
4	*VD	»	IDENT[±cont]	»	*VoiFRIC	
5	*VoiFRIC	»	*VD	»	IDENT[±cont]	
6	*VoiFRIC	»	IDENT[±cont]	»	*VD	

# 4. Factorial typology of segmental distribution

- Ranking (1): \*VD » \*VoIFRIC » IDENT[±cont]  
(this is the ranking for Spanish)

/ba/	*VD	*VoIFRIC	IDENT[±cont]
→ (a) [ba]			
(b) [βa]		*!	*

/aba/	*VD	*VoIFRIC	IDENT[±cont]
(a) [aba]	*!		
→ (b) [aβa]		*	*

## 4. Factorial typology of segmental distribution

- Ranking (1):  $*VD \gg *V_{OI}FRIC \gg IDENT[\pm cont]$   
(this is the ranking for Spanish)

<b>/aβa/</b>	<b>*VD</b>	<b>*V<sub>OI</sub>FRIC</b>	<b>IDENT[±cont]</b>
→ (a) <b>[aβa]</b>		*	
(b) [aba]	*!		*

<b>/βa/</b>	<b>*VD</b>	<b>*V<sub>OI</sub>FRIC</b>	<b>IDENT[±cont]</b>
(a) [βa]		*!	
→ (b) <b>[ba]</b>			*

## 4. Factorial typology of segmental distribution

- Ranking (1): \*VD » \*VoIFRIC » IDENT[±cont]

(this is the ranking for Spanish)

- Outcomes:

/ba/ → **[ba]**

/βa/ → **[ba]**

/aba/ → **[aβa]**

/aβa/ → **[aβa]**

- Distribution:

## 4. Factorial typology of segmental distribution

- Ranking (1): \*VD » \*VoIFRIC » IDENT[±cont]

(this is the ranking for Spanish)

- Outcomes:

/ba/ → [ba]

/βa/ → [ba]

/aba/ → [aβa]

/aβa/ → [aβa]

- Distribution: **complementary** (predictable)

- Faithfulness is lowest — choice of /b/ vs. /β/ in input has *no influence*
- Context-specific M » context-free M — environment determines [b] vs. [β]

## 4. Factorial typology of segmental distribution

- What about all the other candidates?
  - **Other constraints** » \*VOIFRIC, ID[±cont] in Spanish
  - For the rest of **the** discussion, we will keep our focus on languages where such other constraints dominate the constraints under discussion
  - Why? Only because we are interested in **how constraints can predict distribution patterns between two segments** like [b], [β]
    - Other ways to satisfy \*VOIFRIC, \*VD are also predicted to occur! — that's just a separate discussion topic

## 4. Factorial typology of segmental distribution

- What happens when we do the same thing for all the other rankings in this factorial typology?

/ba/	*VD	*V <sub>OI</sub> FRIC	IDENT[±cont]
(a) [ba]			
(b) [βa]		*	*

/aba/	*VD	*V <sub>OI</sub> FRIC	IDENT[±cont]
(a) [aba]	*		
(b) [aβa]		*	*

## 4. Factorial typology of segmental distribution

- What happens when we do the same thing for all the other rankings in this factorial typology?

/aβa/	*VD	*V <sub>OI</sub> FRIC	IDENT[±cont]
(a) [aβa]		*	
(b) [aba]	*		*

/βa/	*VD	*V <sub>OI</sub> FRIC	IDENT[±cont]
(a) [βa]		*	
(b) [ba]			*



## 4. Factorial typology of segmental distribution

- Ranking (2): IDENT[±cont] » \*VOIFRIC » \*VD
- Ranking (3): IDENT[±cont] » \*VD » \*VOIFRIC

- Outcomes:

/ba/ →

/βa/ →

/aba/ →

/aβa/ →

## 4. Factorial typology of segmental distribution

- Ranking (2): IDENT[±cont] » \*VOIFRIC » \*VD
- Ranking (3): IDENT[±cont] » \*VD » \*VOIFRIC

- Outcomes:

/ba/ → **[ba]**

/βa/ → **[βa]**

/aba/ → **[aba]**

/aβa/ → **[aβa]**

- Distribution:

## 4. Factorial typology of segmental distribution

- Ranking (2): IDENT[±cont] » \*VOIFRIC » \*VD
- Ranking (3): IDENT[±cont] » \*VD » \*VOIFRIC
  - Outcomes:

/ba/	→	<b>[ba]</b>	/βa/	→	<b>[βa]</b>
/aba/	→	<b>[aba]</b>	/aβa/	→	<b>[aβa]</b>
  - Distribution: **contrastive** (unpredictable)  
**Note the presence of “minimal pairs”!**
    - Faithfulness is highest — input /b/ and /β/ both survive unchanged, no matter what
  - What is/are morpheme UR(s) here? Can we tell?

## 4. Factorial typology of segmental distribution

- Ranking (4): \*VD » IDENT[±cont] » \*VoIFRIC

- Outcomes:

/ba/ →

/βa/ →

/aba/ →

/aβa/ →

## 4. Factorial typology of segmental distribution

- Ranking (4): \*VD » IDENT[±cont] » \*VOIFRIC

- Outcomes:

/ba/ → **[ba]**

/βa/ → **[βa]**

/aba/ → **[aβa]**

/aβa/ → **[aβa]**

- Distribution:

## 4. Factorial typology of segmental distribution

- Ranking (4): \*VD » IDENT[±CONT] » \*VOIFRIC

- Outcomes:

/ba/ → [ba]                      /βa/ → [βa]

/aba/ → [aβa]                    /aβa/ → [aβa]

- Distribution: **neutralization**

Note “minimal pair” [ba] ≠ [βa], but /aba/ → [aβa]

- \*VD: ‘special’ segment in special context
- Otherwise, faithfulness prevails
- What is/are morpheme UR(s) here? Can we tell?

## 4. Factorial typology of segmental distribution

- Ranking (5): \*VOIFRIC » \*VD » IDENT[±cont]
- Ranking (6): \*VOIFRIC » IDENT[±cont] » \*VD

- Outcomes:

/ba/ →

/βa/ →

/aba/ →

/aβa/ →

## 4. Factorial typology of segmental distribution

- Ranking (5): \*VOIFRIC » \*VD » IDENT[±cont]
- Ranking (6): \*VOIFRIC » IDENT[±cont] » \*VD
  - Outcomes:

/ba/	→	<b>[ba]</b>	/βa/	→	<b>[ba]</b>
/aba/	→	<b>[aba]</b>	/aβa/	→	<b>[aba]</b>
  - Distribution:



## 4. Factorial typology of segmental distribution

- Ranking (5): \*<sub>VoI</sub>FRIC » \*VD » IDENT[±cont]
- Ranking (6): \*<sub>VoI</sub>FRIC » IDENT[±cont] » \*VD
  - Outcomes:

/ba/	→	<b>[ba]</b>	/βa/	→	<b>[ba]</b>
/aba/	→	<b>[aba]</b>	/aβa/	→	<b>[aba]</b>
  - Distribution: **“inventory gap”** (illegal segment)  
Note that there is no [β] in any output ever
    - ‘Special’ segment is banned, regardless of context and regardless of input
    - This is how OT handles **absent** segments

## 4. Factorial typology of segmental distribution

- **Summary** of rankings and distribution patterns:

(1)	<b>*VD</b> » <b>*VoIFRIC</b> » IDENT[±cont]	predictable
(2)	IDENT[±cont] » *COR-DORS » *VD	contrastive
(3)	IDENT[±cont] » *VD » *VoIFRIC	
(4)	<b>*VD</b> » IDENT[±cont] » *VoIFRIC	neutralization
(5)	<b>*VoIFRIC</b> » *VD » IDENT[±cont]	inventory gap
(6)	<b>*VoIFRIC</b> » IDENT[±cont] » *VD	

Faithfulness | Context-specific M | Context-free M

## 4. Factorial typology of segmental distribution

- Implications of the OT approach to segmental distribution:
  - If some language has a context-specific allophone and a default (“elsewhere”) allophone...
  - ...which one is predicted to be an illegal segment in another language?
- Rule-based phonology cannot make this connection

## 5. Summary: Segmental distribution in OT

- General ranking for **predictable distribution**:  
Context-specific M » Context-free M » F
- General ranking for **contrastive distribution**:  
F » { Context-specific M , Context-free M }
- General ranking for **neutralization**:  
Context-specific M » F » Context-free M
- General ranking for **inventory gap**:  
Context-free M » { Context-specific M , F }  
→ One lg's **specific allophone** is another lg's **gap!**

## 6. Gaps in factorial typology (Myers 2002)

- To satisfy a M constraint (2), OT predicts a wide range of F violations (3) that could be used (from Myers 2002)

(2) \*N<sub>0</sub>: A nasal cannot be followed by a voiceless obstruent.

(3) (a) IDENT-LAR: If an output segment has an input correspondent, the two must agree in all laryngeal feature specifications (i.e. [voice], [spread glottis], [constricted glottis]).

(b) IDENT-NASAL: If an output segment has an input correspondent, the two must agree in [nasal].

(c) IDENT-MAJOR: If an output segment has an input correspondent, the two must agree in the major class features [consonantal] and [sonorant].

(d) MAX: Every segment in the input must have a correspondent in the output.

(e) DEP: Every segment in the output must have a correspondent in the input.

(f) LINEARITY: If a string of output segments have input correspondents, the two strings must correspond in all linear order relations among their members.

## 6. Gaps in factorial typology (Myers 2002)

- What actually happens in lgs with \*NT effects?

*attested*

*not attested*

(a) voicing assimilation (e) **epenthesis**

(b,c) denasalization (f) **metathesis**

(d) deletion

- **Why** no epenthesis or metathesis?
  - There are *gaps* in the predicted factorial typology
  - But, it's hard to argue that this is because we are assuming the **wrong constraints!**

## 6. Gaps in factorial typology (Myers 2002)

- Myers's proposal:
  - NT sequences are not always accurately produced and/or perceived
  - This kind of **variability in the transmission** includes things that look like assimilation, denasalization, deletion
  - But **not** things that look like epenthesis or metathesis

## 6. Gaps in factorial typology (Myers 2002)

- The core idea: Some gaps in factorial typology are there for **diachronic** reasons
  - What causes a language to change its phonological grammar? → Breakdown in transmission due to **misperception** by learners
  - But, only certain types of misperception arise
  - Some patterns predicted by factorial typology will never have a chance to be learned
- Gaps in factorial typology: also known as the ***too-many-solutions problem*** (Steriade 2008)



## 6. Gaps in factorial typology (Myers 2002)

- Can diachronic change explain *everything* about phonology? Can we essentially get rid of the idea that we have a synchronic mental grammar entirely?
  - Yes! (Blevins 2004, Blevins & Garrett 2004)
  - No! (Kiparsky 2006) — but diachronic change may explain *some* things

## 7. Implications

- Can we solve some of the too-many-solutions problems by changing the way OT works?
  - **Harmonic Grammar / MaxEnt** (Pater 2009, etc.)
    - Maybe the constraints are not ranked in terms of strict domination, but weighted
    - Lower-weighted constraint violations can, in some cases, “gang up” on a higher-ranked one

## 7. Implications

- Can we solve some of the too-many-solutions problems by changing the way OT works?
  - **Harmonic Serialism** (McCarthy 2000, 2016)
    - Maybe GEN makes “one change at a time”
    - The OT grammar proceeds serially until the output is completely faithful to the input

## 7. Implications

- These alternatives to classic OT have been proposed for multiple reasons, but the too-many-solutions problem is one category of argument you will frequently see

## 7. Implications

- Is the too-many-solutions problem really a *problem* if we model the way factorial typology interfaces with factors like phonetics and diachronic change?
  - Moreton (2008: 83-84) uses these terms:
    - ***channel bias*** — “phonetically systematic errors in transmission between speaker and hearer, caused largely by subtle phonetic interactions which serve as precursors for phonologisation...”
    - ***analytic bias*** — “cognitive biases which facilitate the learning of some phonological patterns and inhibit that of others. One hypothetical type of analytic bias [is] Universal Grammar...”

## 7. Implications

- On this view, can we see factorial typology as a way of studying **analytic bias** specifically?

## 7. Implications

- Another interesting question:

If features, or constraints, are **emergent** (learned, as in Mielke 2004), what does “factorial typology” of segmental distribution look like?

# References

(some available online as preprints; check author web pages)

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