# Computation, learning, and typology

## *Class 8: Process interaction*

Adam Albright and Eric Baković

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creteling2023.phonology.party

# The classical typology

# Feeding, bleeding, and their counter-orders

| | $Q(P(x))$ | $P(Q(x))$ | |
|---|---|---|---|
| $P$ **causes** application of $Q$ | $P$ **feeds** $Q$ | $P$ **counterfeeds** $Q$ | — $Q$ **underapplies** |
| $P$ **prevents** application of $Q$ | $P$ **bleeds** $Q$ | $P$ **counterbleeds** $Q$ | — $Q$ **overapplies** |
| | **transparent** | **opaque** | |

# Feeding, bleeding, and their counter-orders

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- Kiparsky (1968): Feeding & counterbleeding: ‘maximal utilization’

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- Kiparsky (1968): Feeding & counterbleeding: ‘maximal utilization’
- Kiparsky (1971, 1973): opacity is hard to learn

# Feeding, bleeding, and their counter-orders

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- Kiparsky (1968): Feeding & counterbleeding: ‘maximal utilization’
- Kiparsky (1971, 1973): opacity is hard to learn
- McCarthy (1999), a.m.o.: classic OT ‘can’t do opacity’

# Transparent feeding

*Example based on Russian*

$P$ : I $\longrightarrow \varnothing$ / C ___ #  (deletion)

$Q$ : [−son] $\longrightarrow$ [−voi] / ___ #  (devoicing)

✓$Q(P(x))$ : /grebl/ $\xrightarrow{P}$ greb $\xrightarrow{Q}$ grep ‘row (m.pst)’  (feeding, transparent)

$P(Q(x))$ : /grebl/ $\xrightarrow{Q}$ grebl $\xrightarrow{P}$ greb  (counterfeeding, $Q$ underapplies)

# Opaque counterfeeding (underapplication)

*Example based on Bedouin Arabic*

$P$ : [−cons] $\longrightarrow$ [+syll] / C ___ # (vocalization)

$Q$ : a $\longrightarrow$ i / ___ CV (raising)

$Q(P(x))$ : /badw/ $\xrightarrow{P}$ badu $\xrightarrow{Q}$ bidu (feeding, transparent)

✓$P(Q(x))$ : /badw/ $\xrightarrow{Q}$ badw $\xrightarrow{P}$ badu ‘Bedouin’ ($Q$ underapplies)

# Transparent bleeding

*Example based on Lamba*

$P$ : i $\longrightarrow$ e / $\begin{bmatrix} -\text{high} \\ -\text{low} \end{bmatrix}$ $C_0$ ___ (lowering)

$Q$ : s $\longrightarrow$ ʃ / ___ i (palatalization)

✓$Q(P(x))$ : /kosika/ $\xrightarrow{P}$ koseka $\xrightarrow{Q}$ koseka ‘be strong (neut.)’ (bleeding, transparent)

$P(Q(x))$ : /kosika/ $\xrightarrow{Q}$ koʃika $\xrightarrow{P}$ koʃeka (counterbleeding, $Q$ overapplies)

# Opaque counterbleeding (overapplication)

*Example based on Polish*

$P$ : [−son] ⟶ [−voi] / ___ # (devoicing)

$Q$ : o ⟶ u / ___ $\begin{bmatrix}+\text{voi}\\-\text{nas}\end{bmatrix}$ # (raising)

$Q(P(x))$ : /ʒwob/ $\xrightarrow{P}$ ʒwop $\xrightarrow{Q}$ ʒwop (bleeding, transparent)

✓$P(Q(x))$ : /ʒwob/ $\xrightarrow{Q}$ ʒwub $\xrightarrow{P}$ ʒwup ‘crib’ (counterbleeding, $Q$ overapplies)

# — HARD TURN! —

# Background

Baković (2005)
Pajak & Baković (2010)

dispreference for ‘sufficiently identical’ adjacent consonants (anti-similarity)

=

dispreference for *completely* identical adjacent consonants (anti-identity, a.k.a. ‘antigemination’)

+

dispreference for feature mismatch between adjacent consonants (anti-disagreement, a.k.a. assimilation)

# Background

*anti-similarity = anti-identity + anti-disagreement*

Empirical consequences:

1. Assimilation dependence.
2. Contextual predictability.
3. Contingent optionality.

   (Bonus: factorial typology.)

# English past tense

Baković (2005)

-əd / {t, d} __

wɛɪt-əd ‘waited’; fɛɪd-əd ‘faded’

**= /d/ and /t/ are ‘sufficiently identical’**

-t / voiceless sounds __

teɪp-t ‘taped’; feɪk-t ‘faked’; reɪs-t ‘raced’

**= voicing assimilation**

-d / voiced sounds __

seɪv-d ‘saved’; geɪn-d ‘gained’;
reɪz-d ‘raised’; feɪl-d ‘failed’

**= elsewhere**

geɪn-d ‘gained’ vs. seɪnt ‘saint’
feɪl-d ‘failed’ vs. felt ‘felt’

# Sufficient identity

Baković (2005)

| /weɪ**t+d**/ | No-XY | Agree-voi | Dep-V | Ident-voi |
|---|---|---|---|---|
| ☞ weɪ**təd** | | | 1 | |
| a. ~ weɪ**td** | 1 W | 1 W | 0 L | |
| b. ~ weɪ**tt** | 1 W | | 0 L | 1 W |

| /weɪ**t+d**/ | No-XX | Agree-voi | Dep-V | Ident-voi |
|---|---|---|---|---|
| ☞ weɪ**təd** | | | 1 | |
| a. ~ weɪ**td** | | 1 W | 0 L | |
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# Sufficient identity

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|---|---|---|---|---|
| ☞ weɪtəd | | | 1 | |
| a. ~ weɪtd | | 1 W | 0 L | |
| b. ~ weɪtt | 1 W | | 0 L | 1 W |

| /weɪt+d/ | No-XY | Agree-voi | Dep-V | Ident-voi |
|---|---|---|---|---|
| ☞ weɪtəd | | | 1 | |
| a. ~ weɪtd | 1 W | 1 W | 0 L | |
| b. ~ weɪtt | 1 W | | 0 L | 1 W |

***assimilation***

***dependence***

# Consequences

**1. Assimilation dependence.**

Every feature ⓕ ignored for the purposes of determining sufficient identity of adjacent consonants independently assimilates.

# Lithuanian verbal prefixes

Baković (2005)

ap$^{j}$i- / __ {p, b, p$^{j}$, b$^{j}$} **= p, b, p$^{j}$, b$^{j}$ are 'sufficiently identical'**

ap$^{j}$i-put$^{j}$i, ap$^{j}$i-bar$^{j}$t$^{j}$i, ap$^{j}$i-p$^{j}$iːl$^{j}$t$^{j}$i, ap$^{j}$i-b$^{j}$er$^{j}$t$^{j}$i

ap$^{j}$- / __ R$^{j}$, K$^{j}$ **= palatalization assimilation**

ap$^{j}$-l$^{j}$en$^{j}$k$^{j}$t$^{j}$i, ap$^{j}$-t$^{j}$em$^{j}$d$^{j}$iːt$^{j}$i, ap$^{j}$-k$^{j}$el$^{j}$aut$^{j}$i

ab- / __ G **= obstruent voicing assimilation**

ab-dras$^{j}$k$^{j}$iːt$^{j}$i, ab-gaut$^{j}$i

ab$^{j}$- / __ G$^{j}$ **= both assimilations**

ab$^{j}$-d$^{j}$eg$^{j}$t$^{j}$i, ab$^{j}$-ʒ$^{j}$el$^{j}$t$^{j}$i, ab$^{j}$-g$^{j}$iːd$^{j}$iːt$^{j}$i

ap- / __ R, K **= elsewhere**

ap-raʃ$^{j}$iːt$^{j}$i, ap-tar$^{j}$t$^{j}$i, ap-ʃauk$^{j}$t$^{j}$i, ap-kal$^{j}$b$^{j}$et$^{j}$i

# Lithuanian verbal prefixes

Baković (2005)

at$^{j}$i- / __ {t, d, t$^{j}$, d$^{j}$} **= t, d, t$^{j}$, d$^{j}$ are 'sufficiently identical'**

at$^{j}$i-taik$^{j}$i:t$^{j}$i, at$^{j}$i-duot$^{j}$i, at$^{j}$i-t$^{j}$eis$^{j}$t$^{j}$i, at$^{j}$i-d$^{j}$et$^{j}$i

at$^{j}$- / __ R$^{j}$, K$^{j}$ **= palatalization assimilation**

at$^{j}$-l$^{j}$eis$^{j}$t$^{j}$i, at$^{j}$-p$^{j}$aut$^{j}$i, at$^{j}$-k$^{j}$el$^{j}$t$^{j}$i

ad- / __ G **= obstruent voicing assimilation**

ad-buk$^{j}$t$^{j}$i, ad-gaut$^{j}$i

ad$^{j}$- / __ G$^{j}$ **= both assimilations**

ad$^{j}$-b$^{j}$ek$^{j}$t$^{j}$i, ad$^{j}$-g$^{j}$i:t$^{j}$i

at- / __ R, K **= elsewhere**

at-ra$\int^{j}$t$^{j}$i, at-pra$\int^{j}$i:t$^{j}$i, at-$\int$auk$^{j}$t$^{j}$i, at-ko:p$^{j}$t$^{j}$i

# Lithuanian verbal prefixes

Baković (2005)

**t, d, $t^j$, $d^j$ are 'sufficiently identical'**

*assimilation*

**palatalization assimilation**

*dependence*

**obstruent voicing assimilation**

# Lithuanian verbal prefixes

Baković (2005)

| /ap-bʲerʲtʲi/ | No-XX | Agr-voi | Agr-pal | Dep | Id-voi | Id-pal |
|---|---|---|---|---|---|---|
| ☞ apʲi-bʲerʲtʲi | | | | 1 | | 1 |
| a. ~ ap-bʲerʲtʲi | | $_1$ W | $_1$ W | $_0$ L | | $_0$ L |
| b. ~ apʲ-bʲerʲtʲi | | $_1$ W | | $_0$ L | | $_1$ |
| c. ~ ab-bʲerʲtʲi | | | $_1$ W | $_0$ L | $_1$ W | $_0$ L |
| d. ~ abʲ-bʲerʲtʲi | $_1$ W | | | $_0$ L | $_1$ W | $_0$ L |

***assimilation***

***dependence***

# Polish proclitics

Pajak & Baković (2010)

*Note: we'll return to this condition shortly.*

zɛ- / __ {s, z, ɕ, ʑ, ʂ, ʐ} C = **s, z, ɕ, ʑ, ʂ, ʐ are 'sufficiently identical'**

zɛ-skawɔ̃, zɛ-znakʲɛm, zɛ-ɕfitɛm, zɛ-ʐrudwa, zɛ-ʂlaxtɔ̃, zɛ-ʐviru

ʑ-/ʐ- / __ {ʑV, d͡ʑ} / {ʐV, d͡ʒ} **= coronal place assimilation**

ʑ-d͡ʑvʲigʲɛm, ʑ-ʑɛ̃bnɔ̃t͡ɕ / ʐ-d͡ʒungli, ʐ-ʐabɔ̃

s- / __ K **= obstruent voicing assimilation**

s-kfasɛm, s-pʂt͡ʂɔwɔ̃, s-sunɔ̃t͡ɕ, s-sɛrɛm

ɕ-/ʂ- / __ {ɕV, t͡ɕ} / {ʂV, t͡ʂ} **= both assimilations**

ɕ-t͡ɕiʂɨt͡ɕ, ɕ-ɕanɛm / ʂ-t͡ʂkafkɔ̃, ʂ-ʂazɛt͡ɕ

z- / __ R, G, V **= elsewhere**

z-bʑikɔvat͡ɕ, z-bʐdɛ̃kʲɛm, z-zamku, z-uxa

# Polish proclitics

Pajak & Baković (2010)

**s, z, ɕ, ʑ, ʂ, ʐ are 'sufficiently identical'**

**coronal place assimilation**

**obstruent voicing assimilation**

*assimilation*

*dependence*

# Polish proclitics

Pajak & Baković (2010)

| /z-ɕfitɛm/ | No-XX/C | Agr-voi | Agr-cor | Dep | Id-voi | Id-cor |
|---|---|---|---|---|---|---|
| ☞ zɛ-ɕfitɛm | | | | 1 | | |
| a. ~ z-ɕfitɛm | | 1 W | 1 W | 0 L | | |
| b. ~ ʑ-ɕfitɛm | | 1 W | | 0 L | | 1 W |
| c. ~ s-ɕfitɛm | | | 1 W | 0 L | 1 W | |
| d. ~ ɕ-ɕfitɛm | 1 W | | | 0 L | 1 W | 1 W |

***assimilation***

***dependence***

# Consequences

**2. Contextual predictability.**

Adjacent all-but-ⓕ identity avoidance is found in all and only the contexts where both adjacent total identity avoidance and ⓕ-assimilation are independently found.

# Polish proclitics

Pajak & Baković (2010)

| Assimilation | before clusters | before singletons |
|---|---|---|
| voicing /v-/ | f-stʂɛlit͡ɕ<br>f-tʂt͡ɕiɲɛ | f-pudɛwku<br>f-kavʲarɲi |
| voicing /z-/ | s-kfasɛm<br>s-pʂt͡ʂɔwɔ̃ | s-pivɛm<br>s-kavɔ̃ |
| coronal place /z-/ | ʑ-d͡ʑvʲigʲɛm<br>ʐ̢-d͡ʐ̢d͡ʐ̢ɔvɲitsɔ̃ | ʑ-d͡ʑupli<br>ʐ̢-d͡ʐ̢ungli |
| both /z-/ | ɕ-t͡ɕmɔ̃<br>ʂ-t͡ʂkafkɔ̃ | ɕ-t͡ɕiʂɨt͡ɕ<br>ʂ-t͡ʂarɔd͡ʑɛjɛm |

# Polish proclitics

Pajak & Baković (2010)

| Assimilation | before clusters | before singletons |
|---|---|---|
| Total identity avoidance | *only* before clusters | *not* before singletons |
| /v-/ | vɛ-vgwɛ̃bʲɛɲu<br>vɛ-vʐɛɕɲu | v-vanɲɛ<br>(*vɛ-vanɲɛ) |
| /z-/ | zɛ-znakʲɛm<br>zɛ-zvʲɛʐɛ̃t͡ɕi t͡ɕ | z-zamku<br>(*zɛ-zamku) |

# Polish proclitics

Pajak & Baković (2010)

| Assimilation | before clusters | before singletons |
|---|---|---|
| Total identity avoidance | *only* before clusters | *not* before singletons |
| Sufficient identity avoidance | *only* before clusters | *not* before singletons |
| all but voicing /v-/ | vɛ-frunɔ͡tɕ | f-fɔtɛlu (*vɛ-fɔtɛlu) |
| all but voicing /z-/ | zɛ-skawɔ̃ | s-sunɔ̃͡tɕ (*zɛ-sunɔ̃͡tɕ) |
| all but cor. pl. /z-/ | zɛ-ʑrudwa<br>zɛ-ʐviru | ʑ-ʑɛ̃bnɔ̃͡tɕ (*zɛ-ʑɛ̃bnɔ̃͡tɕ) |
| all but both /z-/ | zɛ-ɕfitɛm<br>zɛ-ʂlaxtɔ̃ | ɕ-ɕanɛm (*zɛ-ɕanɛm) |

# Polish proclitics

Pajak & Baković (2010)

| Assimilation | before clusters | before singletons |
|---|---|---|
| Total identity avoidance | *only* before clusters | *not* before singletons |
| Sufficient identity avoidance | *only* before clusters | *not* before singletons |

***contextual predictability***

# Consequences

## 3. Contingent optionality.

In contexts where ⓕ-assimilation applies optionally, all-but-ⓕ identity avoidance is also optional.

# Polish proclitics

Pajak & Baković (2010)

| optional assimilation | singleton fricative | singleton affricate |
|---|---|---|
| voiceless alveopalatal | s-ɕanɛm ~ ɕ-ɕanɛm | s-t͡ɕiʂɨt͡ɕ ~ ɕ-t͡ɕiʂɨt͡ɕ |
| voiceless postalveolar | s-ʂazɻɛt͡ɕ ~ ʂ-ʂazɻɛt͡ɕ | s-t͡ʂapkɔ̃ ~ ʂ-t͡ʂapkɔ̃ |
| voiced alveopalatal | z-ʑɛ̃bnɔ̃t͡ɕ ~ ʑ-ʑɛ̃bnɔ̃t͡ɕ | z-d͡ʑupli ~ ʑ-d͡ʑupli |
| voiced postalveolar | z-ʐabɔ̃ ~ ʐ-ʐabɔ̃ | z-d͡ʐungli ~ ʐ-d͡ʐungli |

# Polish proclitics

Pajak & Baković (2010)

| contingent optionality | affricate in cluster: optional assimilation | fricative in cluster: optional epenthesis |
|---|---|---|
| voiceless alveopalatal | s-t͡ɕmɔ̃ ~ ʂ-t͡ɕmɔ̃ | s-ɕfitɛm ~ zɛ-ɕfitɛm |
| voiceless postalveolar | s-t͡ʂkafkɔ̃ ~ ʂ-t͡ʂkafkɔ̃ | s-ʂlaxtɔ̃ ~ zɛ-ʂlaxtɔ̃ |
| voiced alveopalatal | z-d͡ʑvʲigʲɛm ~ ʑ-d͡ʑvʲigʲɛm | z-ʑrudwa ~ zɛ-ʑrudwa |
| voiced postalveolar | z-d͡ʒmakʲɛm ~ ʒ-d͡ʒmakʲɛm | z-ʒviru ~ zɛ-ʒviru |

***contingent optionality***

# Polish proclitics

Pajak & Baković (2010)

Higher-ranked AGREE-COR inactive: no assimilation…

| /z-dʑupli/ | NO-XX/C | ~~AGR-COR~~ | DEP | ID-COR | AGR-COR |
|---|---|---|---|---|---|
| ☞ z-dʑupli | | | | | 1 |
| a. ~ zɛ-dʑupli | | | $_{1}$ W | | $_{0}$ L |
| b. ~ ʑ-dʑupli | | | | $_{1}$ W | |

…and no epenthesis.

| /z-ʑrudwa/ | NO-XX/C | ~~AGR-COR~~ | DEP | ID-COR | AGR-COR |
|---|---|---|---|---|---|
| ☞ z-ʑrudwa | | | | | 1 |
| a. ~ zɛ-ʑrudwa | | | $_{1}$ W | | $_{0}$ L |
| b. ~ ʑ-ʑrudwa | $_{1}$ W | | $_{0}$ L | $_{1}$ W | |

# Polish proclitics

Pajak & Baković (2010)

Higher-ranked AGREE-COR active: assimilation…

| /ʒ-dʒupli/ | NO-XX/C | AGR-COR | DEP | ID-COR | ~~AGR-COR~~ |
|---|---|---|---|---|---|
| ☞ ʒ-dʒupli | | | | 1 | |
| a. ∼ z-dʒupli | | 1 W | | 0 L | |
| b. ∼ zɛ-dʒupli | | | 1 W | 0 L | |

…and epenthesis.

| /z-ʒrudwa/ | NO-XX/C | AGR-COR | DEP | ID-COR | ~~AGR-COR~~ |
|---|---|---|---|---|---|
| ☞ zɛ-ʒrudwa | | | 1 | | |
| a. ∼ z-ʒrudwa | | 1 W | 1 W | | |
| b. ∼ ʒ-ʒrudwa | 1 W | | 0 L | 1 W | |

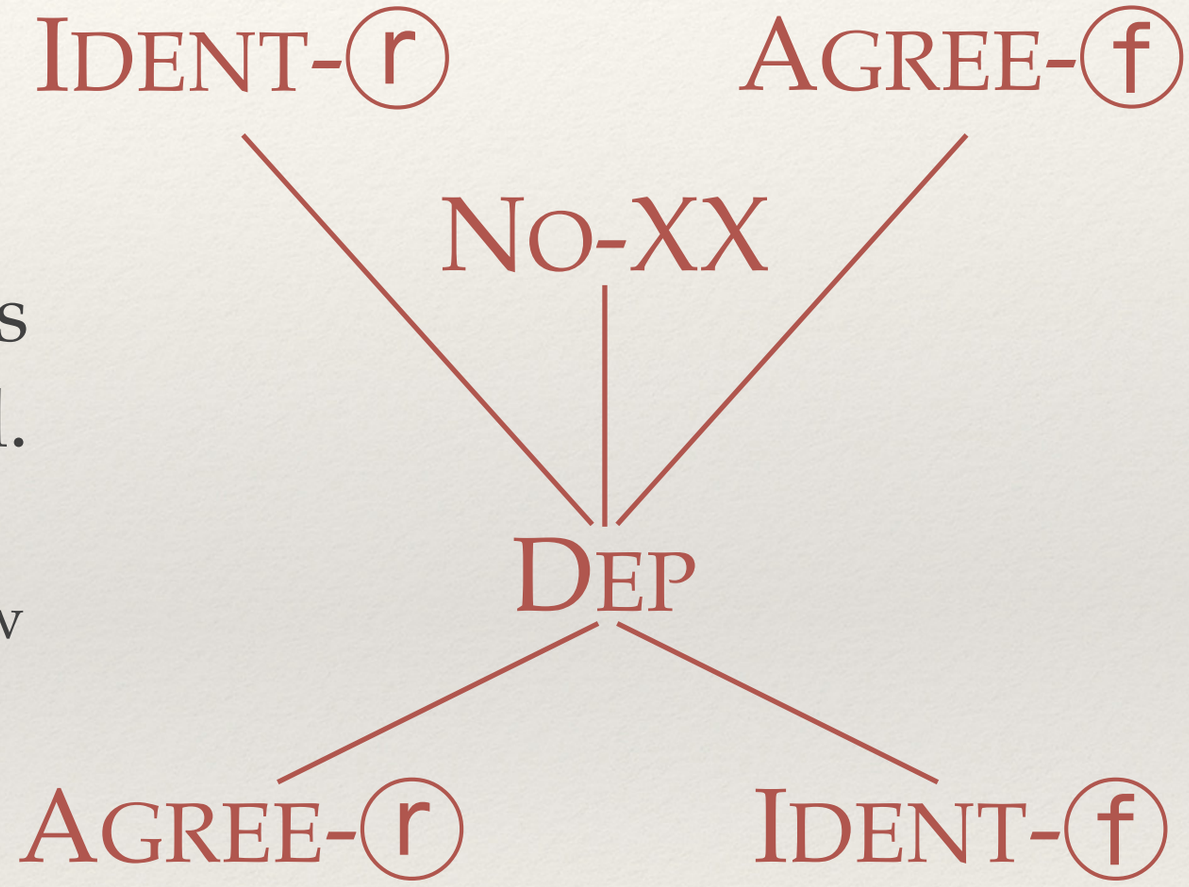
# Bonus: factorial typology

Baković (2005)
Odden (1988)
Rose (2000)
Reiss (2003)

Insert a vowel…

…only if flanking consonants are sufficiently identical.

e.g. English, Lithuanian, Polish, Hebrew




ⓕ = feature(s) ignored for sufficient identity; ⓡ = remaining features

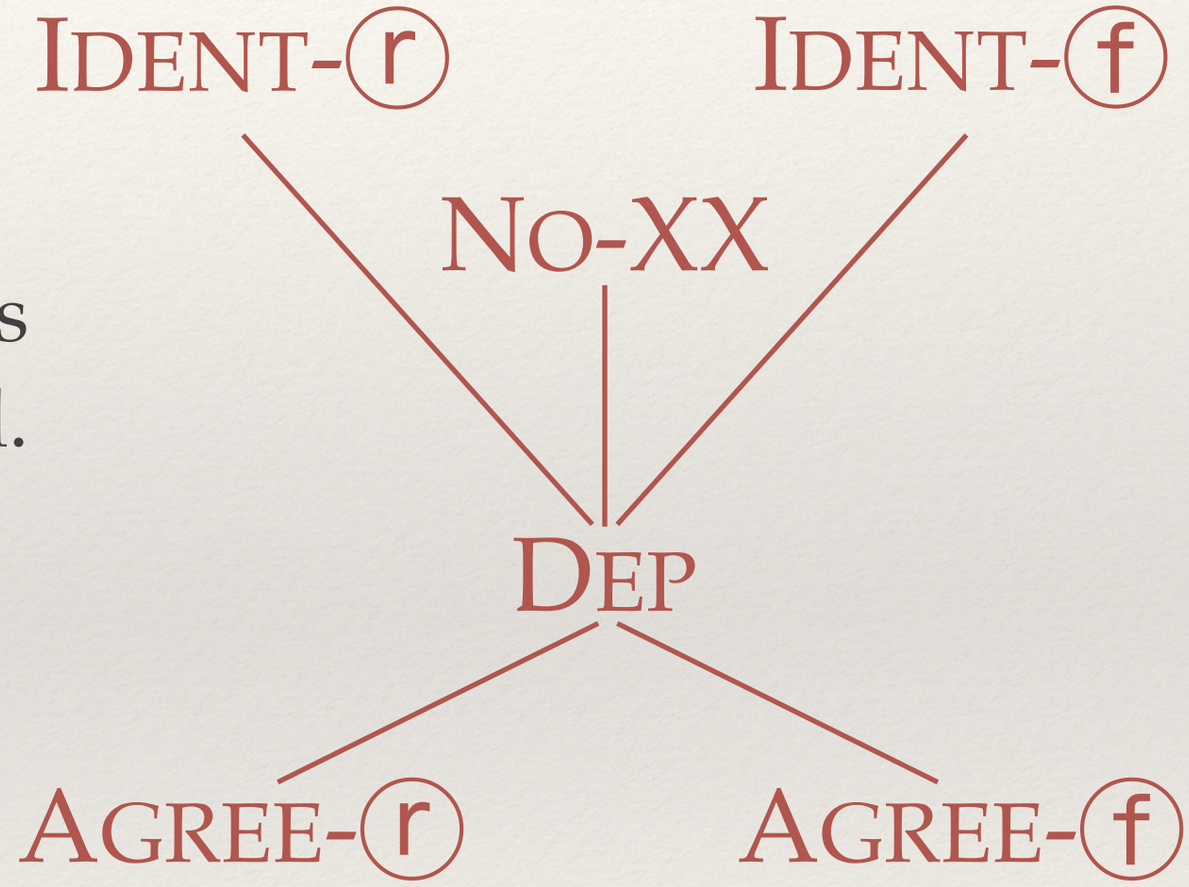
# Bonus: factorial typology

Baković (2005)
Odden (1988)
Rose (2000)
Reiss (2003)

Insert a vowel…

…only if flanking consonants are *totally* identical.

e.g. Tondano (within words), Lenakel




ⓕ = feature(s) ignored for sufficient identity; ⓡ = remaining features

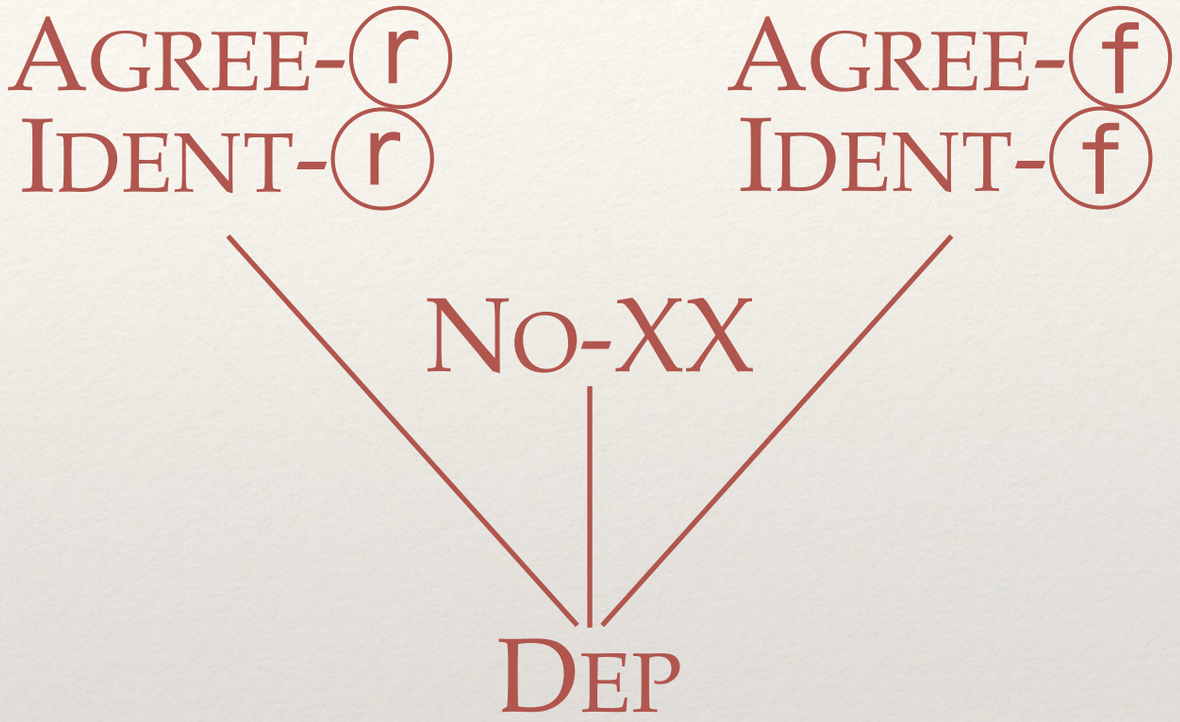
# Bonus: factorial typology

Baković (2005)
Odden (1988)
Rose (2000)
Reiss (2003)

Insert a vowel…

…blindly.

e.g. Hua




ⓕ = feature(s) ignored for sufficient identity; ⓡ = remaining features

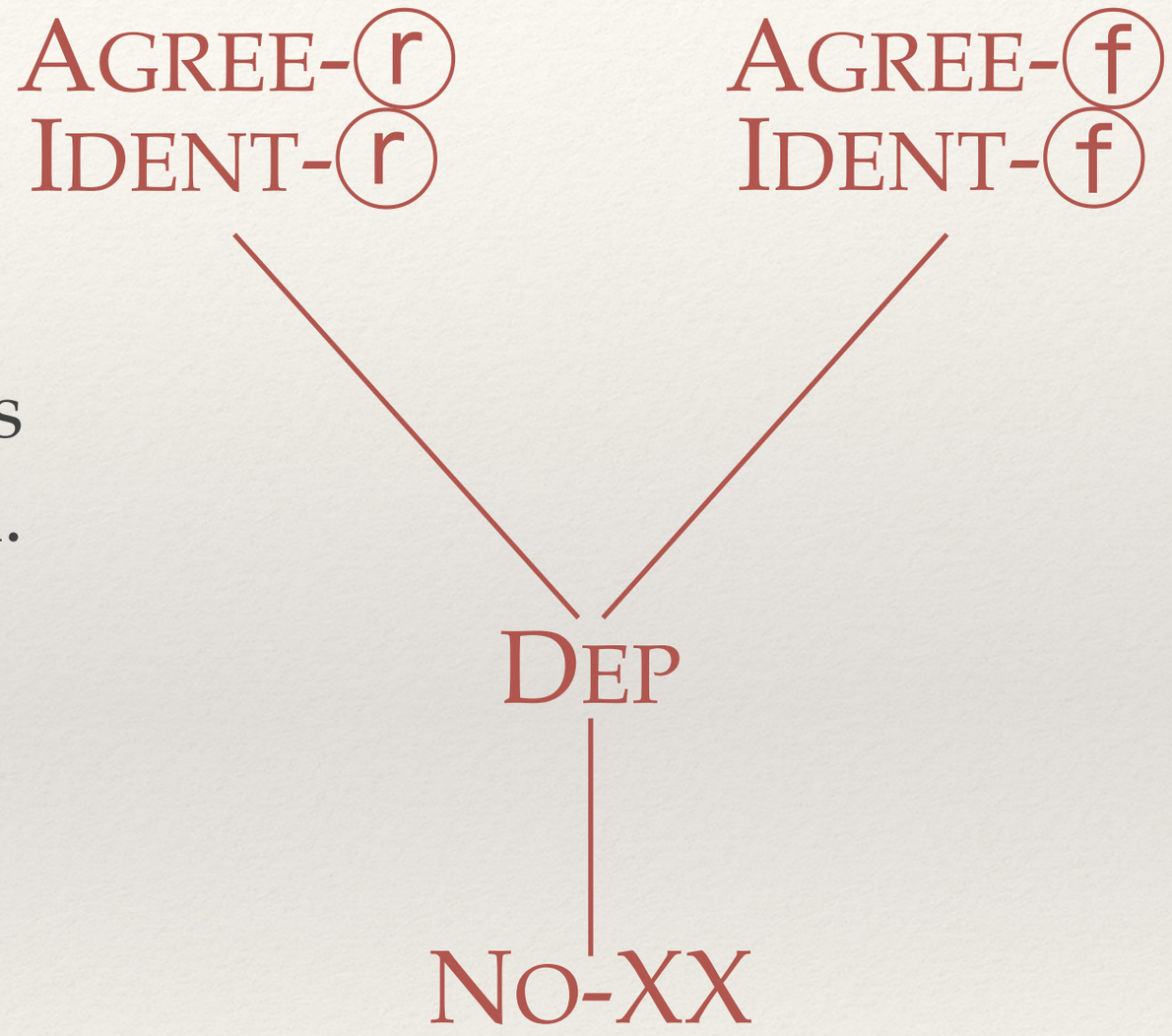
# Bonus: factorial typology

Baković (2005)
Odden (1988)
Rose (2000)
Reiss (2003)

Insert a vowel…

…*unless* flanking consonants are totally identical.

e.g. Tondano (between words)




ⓕ = feature(s) ignored for sufficient identity; ⓡ = remaining features

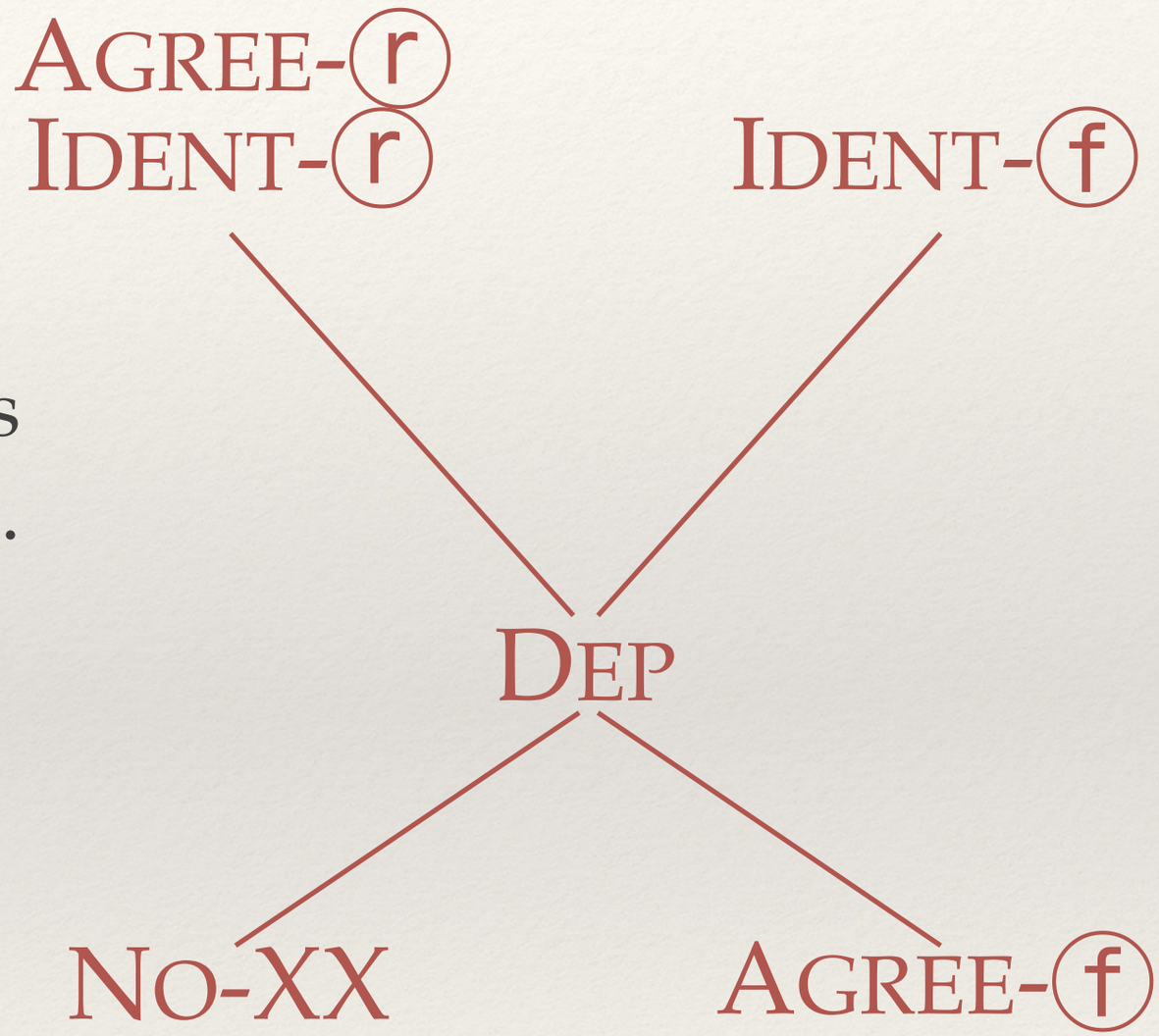
# Bonus: factorial typology

Baković (2005)
Odden (1988)
Rose (2000)
Reiss (2003)

Insert a vowel…

…unless flanking consonants are *sufficiently* identical.

e.g. Yir Yoront




ⓕ = feature(s) ignored for sufficient identity; ⓡ = remaining features

# Consequences

**1. Assimilation dependence.**

Every feature ⓕ ignored in determining sufficient identity of adjacent consonants independently assimilates.

**2. Contextual predictability.**

Adjacent all-but-ⓕ identity avoidance is found in all and only the contexts where both adjacent total identity avoidance and ⓕ-assimilation are independently found.

**3. Contingent optionality.**

In contexts where ⓕ-assimilation applies optionally, all but-ⓕ identity avoidance is also optional.

# Consequences

**1. Assimilation dependence.**

**2. Contextual predictability.** ← □ ∌ No-XY

**3. Contingent optionality.**

# References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