Class 1
Opacity in Phonology

21.05.2021

1 Introduction to Opacity

⋆ **Opaque interactions (i.e. opacity):** cases where some process does or does not apply contrary to expectation because of the way it interacts with other processes.

- Opacity was originally defined by Kiparsky (1971, 1973) in terms of rule application, as in (1).
  - ∗ Over-/under-application and non-surface-true/apparent labels due to McCarthy (1999).

(1) A process $\mathbb{P}$ 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** [*counter-feeding interaction*]
⇝ $\mathbb{P}$ is non-surface-*true* (underapplication opacity)

b. **Instances of B derived by $\mathbb{P}$ in environments other than C_D** [*counter-bleeding interaction*]
⇝ $\mathbb{P}$ is non-surface-*apparent* (overapplication opacity)

- In rule-based terms, such cases can usually be analyzed by saying that some other process $\mathbb{Q}$ applies after $\mathbb{P}$ which obscures the operation of $\mathbb{P}$.

1. **Counter-feeding**: process $\mathbb{Q}$ *introduces* instances of CAD, to which process $\mathbb{P}$ would have applied if given another chance.

(2) Counter-feeding rule ordering interaction

			/CAD/	/CXD/	
1.	$\mathbb{P}$:	A→B / C_D	*CBD*	—	(← *not yet applicable*)
2.	$\mathbb{Q}$:	X→A	—	*CAD*	(← *too late for $\mathbb{P}$ to apply*)
			[CBD]	[CAD]	

2. **Counter-bleeding**: process $\mathbb{Q}$ *removes* part of the context (i.e. affects C and/or D), making it unclear why process $\mathbb{P}$ applied in the first place.

(3) Counter-bleeding rule ordering interaction

			/CAD/		/CAY/
1.	$\mathbb{P}$:	A→B / C_D	*CBD*		—
2.	$\mathbb{Q}$:	D→Y	*CBY*	(← *no longer clear why $\mathbb{P}$ applied*)	—
			[CBY]		[CAY]

- The ordering analysis of opaque interactions can be recapitulated in (certain kinds of) serial constraint-based theories, e.g. Stratal OT. However, this tends to make predictions about the way the opacity fits in with the morphology that aren't independently motivated, or even consistent with the facts.
- Classical Parallel OT has serious trouble with some kinds of opacity, because it deals only with the evaluation of surface structures: opaque processes are by definition those which are either non-surface-true or non-surface-apparent.

2 Counter-feeding opacity: Raising, syncope, and vocalization in Bedouin Hijazi Arabic

- Two classic examples of counter-feeding/underapplication opacity come from Bedouin Hijazi Arabic (Al-Mozainy 1981).
- Parallel OT cannot derive these interactions using just the constraints involved in the independent processes.
  - For one sub-type, though, it can derive the correct result if we allow a more powerful type of faithfulness constraint.
- While Stratal OT can in principle derive all of these types of interactions, the need to fit each process into a specific stratum might not actually jive with the data in this case.

2.1 The data, and rule-based analyses

2.1.1 Syncope and raising: counter-feeding on focus

- This dialect has syncope of high vowels in open syllables:

(4) **High vowel syncope (HVS) rule:** $V_{[+high]} \rightarrow \text{Ø}$ / _CV

- This can be seen in different inflected forms of underlying /CiCiC/ verbs:

(5) High vowel syncope in passive verbs w/ underlying /C$\boxed{\text{i}}$CiC/ stems (· represents syncope site)

Underlying stem	3sg.masc	3sg.fem	1sg	
/ħizim/	ħ·zim	ħiz·m-at	ħ·zim-t	'be tied'
/ħifir/	ħ·fir	ħif·r-at	ħ·fir-t	'be dug'
/ʃirib/	ʃ·rib	ʃir·b-at	ʃ·rib-t	'be drunk'
/libis/	l·bis	lib·s-at	l·bis-t	'be tied'

  - Applies productively to loanwords: e.g. [s·linder] 'cylinder'

- Short low /a/ becomes high [i] in non-final open syllables:

(6) **Low vowel raising (LVR) rule:** /a/ → [i] / _CV

- This process applies in some of the same inflected forms for underlying /CaCiC/ verbs:

(7) Vowel raising in active verbs w/ underlying /C$\boxed{\text{a}}$CiC/ stems (underline represents raising site)

Underlying stem	3sg.masc	3sg.fem	1sg	
/samiʕ/	si̲miʕ	sam·ʕ-at	si̲miʕ-t	'hear'
/ʃarib/	ʃi̲rib	ʃar·b-at	ʃi̲rib-t	'drink'
/labis/	li̲bis	lab·s-at	li̲bis-t	'tie'
/salim/	si̲lim	sal·m-at	si̲lim-t	(not sure what the right gloss is here)

⋆ In these cases, /a/ → [i] raising has introduced [i] into an open syllable. This is normally the position where [i] → Ø, but we do not observe deletion.

(8) Raising and deletion in passive vs. active

Passive 3sg.masc	vs.	Active 3sg.masc	
/ʃirib/ → ʃ·rib		/ʃarib/ → ʃi̱rib	(not *ʃ·̱rib)
/libis/ → l·bis		/labis/ → li̱bis	(not *l·̱bis)

∗ It's worth considering whether an anti-homophony condition could be blocking deletion in the active...

- **Standard analysis:** high vowel deletion applies *before* low vowel raising (counter-feeding interaction).

(9) Counter-feeding rule ordering interaction

	Passive 3sg.masc	Active 3sg.masc	
	/ʃirib-Ø/	/ʃarib-Ø/	
1. High vowel deletion	*ʃ·rib*	—	(← *not yet applicable*)
2. Low vowel raising	—	*ʃi̱rib*	(← *too late for HVD to apply*)
	[ʃrib]	[ʃirib]	

- We can see that if we reversed the order, we'd get a transparent feeding interaction:

(10) Feeding rule ordering interaction in Arabic′

	Passive 3sg.masc	Active 3sg.masc
	/ʃirib-Ø/	/ʃarib-Ø/
1. Low vowel raising	—	*ʃi̱rib*
2. High vowel deletion	*ʃ·rib*	*ʃ·̱rib*
	[ʃrib]	[ʃrib]

- This type of counter-feeding interaction is called *counter-feeding on* ***focus***, because both processes affect the same segment (the "focus" of the rules).

→ This type of interaction is consistent with Parallel OT if we allow a certain type of faithfulness constraint.

2.1.2 Raising and vocalization: counter-feeding on environment

- In the same dialect, raising can underapply as well:
  → Raising fails to apply to syllables made open by a glide vocalization process (Johnstone 1967:14).
  ○ NB: As far as I can tell Al-Mozainy (1981) doesn't talk about cases like these.

- Many Arabic languages have an underlying contrast between final vowels and glides, e.g.

(11) Palestinian Arabic

a.	Underlying glide:	*dalu*	'pail'	∼	*dalw-ak*	'your pail'	⇒ /dal**w**/
b.	Underlying vowel:	*ʔabu*	'father'	∼	*ʔabuː-k* (**ʔabw-ak*)	'your father'	⇒ /(ʔ)ab**u**(ː)/

∗ (Maybe it's really just a difference between short and long vowels?)

- Glides are vocalized if not adjacent to a vowel: /dalw/ → [dalu]

- Low vowels that surface in open syllables due to glide vocalization do not undergo raising:

(12) /badw/ 'bedouin' → [b**a**du], not *[b**i**du]

→ **Rule ordering analysis:** Raising > Glide vocalization (counter-feeding)

(13) Counter-feeding LVR

		/badw/	
1.	**Low vowel raising**	—	
2.	**Glide vocalization**	*bad**u***	(← *too late for LVR to apply again*)
		[badu]	

- This type of counter-feeding interaction is called *counter-feeding on **environment***, because the two processes affect different segments, where one of those segments forms part of the environment for the other process.

→ This type of interaction is not amenable to the same faithfulness-based P OT account as counter-feeding on focus.

2.2 Parallel OT

2.2.1 Basic constraints in Parallel OT won't work

- In both of these cases, the interaction of the basic constraints we need for the processes independently can only yield **transparent** interactions in Parallel OT, i.e. **feeding** or **bleeding**, which is obviously not what we want.

(14) Process rankings

a. High vowel deletion: *i/_CV ≫ MAXV-IO
b. Low vowel raising: *a/_CV ≫ IDENT[low]-IO
c. Vocalization: W//V ≫ IDENT[syllabic]-IO

- Notation below:
  - $\{\mathbb{M}_1 \gg \mathbb{F}_1\}$ = process that must apply first in the rule-ordering analysis **(HVD)**
  - $\{\mathbb{M}_2 \gg \mathbb{F}_2\}$ = process that must apply second in the rule-ordering analysis **(LVR)**

- There is no way to rank the constraints which is consistent with the basic processes that will derive the counter-feeding result.

(15) If both $\mathbb{M} \gg \mathbb{F}$ → feeding interaction

/ʃarib-Ø/	*i/_CV	*a/_CV	MAXV-IO	IDENT[low]-IO
a. ʃarib		*!		
b. ☹ ʃirib	*!			*
c. 💣 ʃrib			*	

(16) If $\{\mathbb{M}_2 \gg \mathbb{F}_2\} \gg \{\mathbb{M}_1 \gg \mathbb{F}_1\}$ → feeding interaction

/ʃarib-Ø/	*a/_CV	IDENT[low]-IO	*i/_CV	MAXV-IO
a. ʃarib	*!			
b. ☹ ʃirib		*!	*	
c. 💣 ʃrib				*

(17) If $\{\mathbb{M}_1 \gg \mathbb{F}_1\} \gg \{\mathbb{M}_2 \gg \mathbb{F}_2\} \rightarrow$ bleeding interaction

/ʃarib-Ø/	*i/_CV	MAXV-IO	*a/_CV	IDENT[low]-IO
a. 💣 ʃarib			*	
b. ☹ ʃirib	*!			*
c. ʃrib		*!		

- In order to get candidate (b) with these constraints, you would need MAXV-IO ($\mathbb{F}_1$) and *a/_CV ($\mathbb{M}_2$) to dominate both *i/_CV ($\mathbb{M}_1$) and IDENT[low]-IO ($\mathbb{F}_2$).
  → But this would include the ranking MAXV-IO ≫ *i/_CV, which would mean that high vowel deletion should *never* apply. So this won't work either.

(18) $\mathbb{F}_1, \mathbb{M}_2 \gg \mathbb{F}_2, \mathbb{M}_1 \rightarrow$ "counter-feeding" output

/ʃarib-Ø/	MAXV-IO	*a/_CV	IDENT[low]-IO	*i/_CV
a. ʃarib		*!		
b. ☞ ʃirib			*	*
c. ʃrib	*!			

(19) Wrong result for simple HVD case

/ʃirib-Ø/	MAXV-IO	*a/_CV	IDENT[low]-IO	*i/_CV
a. ʃarib		*!	*	
b. 💣 ʃirib				*
c. ☹ ʃrib	*!			

2.2.2 A workable Parallel OT analysis for counter-feeding on focus

- One way to state the generalization behind the syncope-raising interaction is that underlying /i/ is allowed to delete, but underlying /a/ is not.
- We can write a faithfulness constraint that captures this generalization:

(20) **MAXV$_{[+low]}$-IO:**
Assign a violation * for each [+low] vowel *in the input* that lacks a correspondent in the output.

- We can call this a **"two-level"** faithfulness constraint:
  - There is some property associated with a segment in the input that qualifies it for special faithfulness in the output, even if that property itself is not required to be maintained.

- When this constraint and $\mathbb{M}_2$ both dominate $\mathbb{M}_1$, we can derive counter-feeding.
  - In the absence of MAXV$_{[+low]}$-IO, this ranking would generate feeding (i.e. (21c)).
  → MAXV$_{[+low]}$-IO blocks the second part of the feeding interaction, hence counter-feeding.

(21) Counter-feeding with MAXV$_{[+low]}$-IO

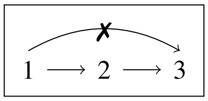
/ʃarib-Ø/	MAXV$_{[+low]}$-IO	*a/_CV	IDENT[low]-IO	*i/_CV	MAXV-IO
a. ʃarib		*!			
b. ☞ ʃirib			*	*	
c. ʃrib	*!				*

⋆ In order to get this to work in Harmonic Serialism, you need to introduce faithfulness constraints that refer back to the underlying form, not just the current input (Hauser & Hughto 2020).

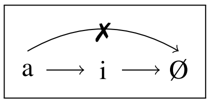
- This interaction is essentially a simple “chain shift”:

(22) Simple chain shifts

a. Schematic (1 → 2 ; 2 → 3 ; 1 ↛ 3)



b. Arabic deletion and raising (a → i ; i → Ø ; a ↛ Ø)



- MAXV$_{[+low]}$-IO is basically a simplified version of a more general type of faithfulness constraint which regulates how many steps along a scale you are allowed to take.
  - i.e., it doesn’t penalize a movement of one step along the scale, but it does penalize a movement of two steps.
  - Often called “distantial faithfulness” or “scalar faithfulness” (Gnanadesikan 1997; cf. Kirchner 1996).

2.2.3 This won’t work for counter-feeding on environment

- If we had some constraint equivalent to MAXV$_{[+low]}$-IO, then we could derive the right result for the raising-vocalization interaction too. But it’s not at all obvious what that constraint would be.

(23) Counter-feeding on environment: raising-vocalization interaction

/badw/			ℂ	W//V	IDENT[syllabic]-IO	*a/_CV	IDENT[low]-IO
a.		badw		*!			
b.	☞	badu			*	*(!)	
c.	(💣)	bidu	*!		*		*
d.		bidw		*!			*

- There’s no obvious way to extend the MAXV$_{[+low]}$-IO–type of analysis to cases of counter-feeding on environment, because the two processes normally refer to different features.

- One common approach has been to use constraint conjunction (Kirchner 1996, *a.o*):

(24) **IDENT[syllabic]-IO & IDENT[low]-IO**
Assign a violation * if IDENT[syllabic]-IO and IDENT[low]-IO are **both** violated (in some local domain).

→ This is an extremely powerful device, and there are problematic issues around locality.

2.3 Stratal OT

- A Stratal OT analysis in principle *can* use just the basic constraints to derive these sorts of counter-feeding interactions, by recapitulating the rule-ordering analysis.

2.3.1 Analysis

- The Stratal OT analysis of the counter-feeding syncope-raising interaction requires the following rankings:

(25) a. Level 1: *i/_CV, IDENT[low]-IO ≫ MAXV-IO ≫ *a/_CV
b. Level 2: *a/_CV, MAXV-IO ≫ IDENT[low]-IO, *i/_CV

Ingredients of these rankings:

- At the first level:
  1. The process that must apply first in the rule-ordering analysis (the one that counter-feeds) is active (i.e. $\mathbb{M}_1 \gg \mathbb{F}_1$).
     → High vowel deletion **active**: *i/_CV ≫ MAXV-IO
  2. The process that must apply second is inactive (i.e. $\mathbb{F}_2 \gg \mathbb{M}_2$).
     → Low vowel raising **inactive**: IDENT[low]-IO ≫ *a/_CV
- At a subsequent level:
  1. The first process is turned off (i.e. $\mathbb{F}_1 \gg \mathbb{M}_1$).
     → High vowel deletion **inactive**: MAXV-IO ≫ *i/_CV
  2. The second process is turned on (i.e. $\mathbb{M}_2 \gg \mathbb{F}_2$).
     → Low vowel raising **active**: *a/_CV ≫ IDENT[low]-IO

⋆ At least for counter-feeding on focus:
- ∘ At first level, $\mathbb{F}_2$ (IDENT[low]-IO) must also dominate $\mathbb{F}_1$ (MAXV-IO), so that it is preferable to perform the normal repair (here, *high vowel deletion*) rather than to make the change in the other direction (here, *lowering to a*).
- ∘ Likewise, at second level, $\mathbb{F}_1$ (MAXV-IO) must also dominate $\mathbb{F}_2$ (IDENT[low]-IO), so you get raising rather than deletion.

(26) Treatment of underlying /a/ in open syllable (counter-feeding interaction)

Level 1: High vowel deletion is active **(does not apply here)**, Low vowel raising is inactive

/ʃarib-Ø/	*i/_CV	IDENT[low]-IO	MAXV-IO	*a/_CV
a. ☞ ʃarib				*
b. ʃirib	*!	*!		
c. ʃrib			*!	

↪ Level 2: Low vowel raising is active **(applies here)**, High vowel deletion is inactive

/ʃarib/	*a/_CV	MAXV-IO	IDENT[low]-IO	*i/_CV
a. ʃarib	*!			
b. ☞ ʃirib			*	*
c. ʃrib		*!		

(27) Treatment of underlying /i/ in open syllable (no process interaction)

Level 1: High vowel deletion is active **(applies here)**, Low vowel raising is inactive

/ʃirib-Ø/	*i/_CV	IDENT[low]-IO	MAXV-IO	*a/_CV
a. ʃarib		*!		*
b. ʃirib	*!			
c. ☞ ʃrib			*	

↪ Level 2: Low vowel raising is active **(does not apply here)**, High vowel deletion is inactive

/ʃrib/	*a/_CV	MAXV-IO	IDENT[low]-IO	*i/_CV
a. ʃarib	*!			
b. ʃirib				*!
c. ☞ ʃrib				

2.3.2 A problem with the actual data

- In the abstract, this analysis works formally. However, there's a potential problem with associating these rankings with the right levels within a restrictive 3-level Stratal OT.

(28) Problem with level ordering and syncope-raising interaction
  a. High vowel deletion obligatorily occurs across word boundaries (Al-Mozainy 1981:49–51)
  → //...**VCiC**#VCV...// → [...**VC**·**C**#VCV...]
  b. Low vowel raising applies "sporadically" across word boundaries (Al-Mozainy 1981:54)
  → //...**VCaC**#VCV...// → [...**VCi̠C**#VCV...] ∼ [...**VCaC**#VCV...]

- In order for a process to apply across word boundaries, it must be active at the *post-lexical* level.
  - Therefore, HVD must be active at the post-lexical level, and so must LVR (at least variably).
- ⋆ If the two processes are active in the same stratum (regardless of which one), we can derive only a feeding or bleeding pattern (as we saw with the basic P OT analysis). This is the wrong result.

⇒ Therefore, for this case, Stratal OT is incorrectly restrictive. By requiring exactly three distinct levels which are tied to the morphology, we cannot bring to bear stratal re-ranking in the necessary way.

- Stratal OT can still derive the right result by using the special faithfulness constraint MAXV$_{[+low]}$-IO.
  - But since Parallel OT can achieve the right result with this constraint without doing any stratal re-ranking, that is a mark in favor of P OT over Stratal OT.
- ∗ **NB:** Parallel OT doesn't have a great way of distinguishing between lexical and post-lexical phonology.

3 Counter-bleeding: Flapping and Canadian Raising in English

- In some dialects of North American English, the processes of flapping and "Canadian Raising" interact opaquely (Joos 1942, Chambers 1973, and then many, many others), specifically as *counter-bleeding*.
  - ∗ Probably best understood as cyclic opacity, but it's more complicated than just that.

3.1 Data

- The process referred to as Canadian Raising raises the nuclei of low diphthongs before voiceless C's.
  - It's an extreme instance of the general fact about English (and many languages) that vowels have shorter duration before voiceless obstruents than voiced obstruents. The raising is a consequence of the shortening.

(29) **Canadian Raising rule:** /aɪ/ → [ʌɪ] / _C$_{[\text{-voice}]}$ (for Canadian English, also /aʊ/ → [ʌʊ])

(30)

No raising (i.e. faithful):	áɪ 'eye'	áɪz 'eyes'	fáɪbɹ̩ 'fiber'
Raising (i.e. process application):		ʌ́ɪs 'ice'	hʌ́ɪpɹ̩ 'hyper'

- Putting aside the interaction we'll be interested in, [aɪ] and [ʌɪ] are in complementary distribution, i.e. allophonic.

- Most dialects of North American English also have a flapping rule, which neutralizes coronal stops to a flap — which, crucially, is [+voice] — (roughly) between a vowel and an unstressed vowel/nucleus.

(31) **Flapping rule:** /t, d/ → [ɾ] / V_V$_{[\text{-stress}]}$

(32)

bɛ́t 'bet'	→	bɛ́ɾɪŋ 'betting'
bɛ́d 'bed'	→	bɛ́ɾɪŋ 'bedding'

- The flapping rule has the potential to bleed the Canadian Raising rule, because it changes a [-voice] segment (/t/) to a [+voice] segment ([ɾ]). Nevertheless, when the two interact, both rules apply:

(33) Interaction between flapping and Canadian raising

a.	ɹʌ́ɪt ‘write’	∼	ɹʌ́ɪɾɹ̩	(*ɹáɪɾɹ̩)	‘writer’	fʌɪt ‘fight’	∼	fʌɪɾɹ̩	(*faɪɾɹ̩)	‘fighter’
b.	ɹáɪd ‘ride’	∼	ɹáɪɾɹ̩		‘rider’	glaɪd ‘glide’	∼	glaɪɾɹ̩		‘glider’

- With respect to the output in ‘writer’/‘fighter’, the Canadian Raising rule has *overapplied*, because there is no voiceless C to trigger it.

3.2 Rule-ordering

- Rule ordering analysis: Canadian Raising > Flapping

(34) Counter-bleeding rule ordering interaction (assume stress applies at some point before flapping)

		UR w/ voiced stop	UR w/ voiceless stop	
		/glaɪ**d**-ɹ/	/faɪ**t**-ɹ/	
1.	**Canadian Raising**	—	fʌ́ɪtɹ̩	
2.	**Flapping**	gláɪɾɹ̩	fʌ́ɪɾɹ̩	(← *destroys environment for C.R.*)
		[gláɪɾɹ̩]	[fʌ́ɪɾɹ̩]	

- We can confirm this is *counter-bleeding* by reversing the order: Canadian Raising fails to apply, because flapping bleeds its environment.

(35) Bleeding rule ordering interaction in English′

		UR w/ voiced stop	UR w/ voiceless stop	
		/gláɪ**d**-ɹ/	/fáɪ**t**-ɹ/	
1.	**Flapping**	gláɪɾɹ̩	fáɪɾɹ̩	(← *destroys environment for C.R.*)
2.	**Canadian Raising**	—	—	(← *environment no longer met*)
		[gláɪɾɹ̩]	*[fáɪɾɹ̩]	

3.3 Basic constraints can’t get this in OT

- Just like for counter-feeding, the interaction of the basic constraints can only yield a transparent interaction.
  - At least for this example, it will always be bleeding. (Not sure if this generalizes to all cases of counter-bleeding.)

(36) Constraints and rankings

a. Canadian Raising: *[aɪ]$C_{\text{[-voice]}}$ ≫ *[ʌɪ] ≫ IDENT[low]-IO
b. Flapping: *V$C_{\text{[COR,-son,-cont]}}V_{\text{[-stress]}}$ (*VTV̆) ≫ IDENT[voice]-IO

- Given these constraints, the non-raising flapping candidate (c) harmonically bounds the desired raising flapping candidate (d).
  - Essentially: you have to flap (and thus voice), so there's no reason to incur the extra markedness violation (*[ʌɪ]) that would result from applying the raising process.
  - ⋆ Faithfulness is irrelevant; the same would hold even if we switched the input to /ʌɪ/.

(37) Bleeding interactions only

i. Bleeding interaction when Flapping ≫ C.R.

/faɪt-ɪŋ/	*[aɪ]$C_{[\text{-voice}]}$	*[ʌɪ]	IDENT[low]-IO	*VTV̌	IDENT[voice]-IO
a. fáɪtɪŋ	*!			*	
b. fʌ́ɪtɪŋ		*!	*	*	
c. 💣 fáɪɾɪŋ					*
d. ☹ fʌ́ɪɾɪŋ		*!	*		*

ii. Bleeding interaction when C.R. ≫ Flapping

/faɪt-ɪŋ/	*VTV̌	IDENT[voice]-IO	*[aɪ]$C_{[\text{-voice}]}$	*[ʌɪ]	IDENT[low]-IO
a. fáɪtɪŋ	*!		*		
b. fʌ́ɪtɪŋ	*!			*	*
c. 💣 fáɪɾɪŋ		*			
d. ☹ fʌ́ɪɾɪŋ		*		*!	*

3.4 In this case, cyclicity is the answer

- There's an obvious solution to the (given the data seen so far): cyclicity
  - All of the opaque alternating cases are polymorphemic with a clear base that has raising in its proper context.
  - → This is a straightforward cyclic effect.

- In a BD-correspondence model, if IDENT[low]-BD ≫ *[ʌɪ], we properly generate the data:

(38) Deriving overapplication via BD-faithfulness

INPUT: /faɪt-ɪŋ/ BASE: [fʌ́ɪt]	ID[low]-BD	*[aɪ]$C_{[\text{-voice}]}$	*[ʌɪ]	ID[low]-IO	*VTV̌	ID[voice]-IO
a. fáɪtɪŋ	*!	*!			*	
b. fʌ́ɪtɪŋ			*	*	*!	
c. fáɪɾɪŋ	*!					*
d. ☞ fʌ́ɪɾɪŋ			*	*		*

- Stratal OT can also get this just fine.
  - Allophonic distribution of [aɪ]∼[ʌɪ] holds only at Level 1. Flapping doesn't apply at Level 1.
  - Level 2 exhibits faithfulness to value of [±low] output by Level 1. Flapping applies at Level 2.
- This is probably reasonable for English, as flapping applies post-lexically (at least under some conditions).

⋆ There's a complication with morpheme-internal sequences... Maybe we'll come back to this in the cyclicty unit.

4 Not all opacity can be done with rules: anti-gemination in Lithuanian

- Lithuanian exhibits a complicated interaction between assimilation and epenthesis, which represents a type of opacity ("cross-derivational feeding") that can't be handled with ordered rules (Baković 2005, 2007).

4.1 The data

- Lithuanian has regressive voicing assimilation (among obstruents) and regressive palatalization assimilation (all consonants), and consonants preceding front vowels are automatically palatalized.
  - Palatalization is semi-contrastive elsewhere (Baković 2007:234, n. 13).
- These processes can be seen with alternations for the verbal prefixes /at-/ and /ap-/:

(39) Lithuanian verbal prefixes: voicing and palatalization assimilation (Baković 2005:290)

a. Voiceless non-palatalized			
at-praʃʲiːtʲi	'to ask'	ap-ʃaukʲtʲi	'to proclaim'
at-koːpʲtʲi	'to rise'	ap-kalʲbʲetʲi	'to slander'
at-rasʲtʲi	'to find'	ap-raʃʲiːtʲi	'to describe'
b. Voiced non-palatalized			
ad-bukʲtʲi	'to become blunt'	ab-drasʲkʲiːtʲi	'to tear'
ad-gautʲi	'to get back'	ab-gautʲi	'to deceive'
c. Voiceless palatalized			
atʲ-pʲautʲi	'to cut off'	apʲ-tʲemʲdʲiːtʲi	'to obscure'
		apʲ-kʲelʲautʲi	'to travel through'
d. Voiced palatalized			
adʲ-bʲekʲtʲi	'to run up'	abʲ-ʒʲelʲtʲi	'to become overgrown'
		abʲ-gʲiːdʲiːtʲi	'to heal'
atʲ-lʲeisʲtʲi	'to forgive'	apʲ-lʲenʲkʲtʲi	'to spare'

- However, just in case the result of assimilation would be a geminate (i.e. the adjacent consonants are underlyingly identical with the exception of voicing and palatalization), we instead get **epenthesis** of [i] (with subsequent automatic palatalization) **without any assimilation**.

(40) Lithuanian verbal prefixes: epenthesis (Baković 2007:234)

atʲi-taikʲiːtʲi	(*at-t...)	'to make fit well'	apʲi-putʲi	(*ap-p...)	'to grow rotten'
atʲi-tʲeisʲtʲi	(*atʲ-tʲ...)	'to adjudicate'	apʲi-pʲiːlʲtʲi	(*apʲ-pʲ...)	'to spill something on'
atʲi-duotʲi	(*ad-d...)	'to give back'	apʲi-barʲtʲi	(*ab-b...)	'to scold a little bit'
atʲi-dʲetʲi	(*adʲ-dʲ...)	'to delay'	apʲi-bʲerʲtʲi	(*abʲ-bʲ...)	'to strew all over'

- This is a case of "anti-gemination" (McCarthy 1986; Yip 1988):

(41) Anti-gemination

a. A vowel deletion process is blocked just in case it would create a geminate

b. **A vowel epenthesis process occurs only to block the creation of geminates**

Why is this an opaque interaction?

- ○ If we assume that the epenthesis process is driven by anti-gemination (more below), then it should only apply to actual geminates.
- ○ But we don't know we have a geminate until assimilation has applied.
- ○ Yet the results of assimilation are not reflected in the epenthetic form.
- → Therefore, the conditioning environment for the epenthesis rule is *non-surface-apparent* (overapplication opacity), similar to counter-bleeding.

- Baković (2007) calls this "cross-derivational feeding", because it requires reference to the outcome of an alternative derivation.

4.2 Baković's OT analysis

- The anti-gemination can be easily modeled in OT with the following constraints:

(42) Constraints for Baković (2005, 2007) analysis (Baković 2007:239)

a. i. **AGREE[voi]:** Assign a violation for each pair of adjacent obstruents that differ in voicing.
   ii. **AGREE[pal]:** Assign a violation for each pair of adjacent consonants that differ in palatalization.

b. i. **IDENT[voi]:** Assign a violation for each change in voicing from input to output.
   ii. **IDENT[pal]:** Assign a violation for each change in palatalization from input to output.

c. **NOGEM:** Assign a violation for each pair of adjacent identical consonants (i.e. geminates).

d. **DEP(V):** Assign a violation for each epenthetic vowel.

- When gemination is not at stake, we get assimilation (43), so we know that the AGREE constraints dominate the IDENT constraints. Since we don't get epenthesis to avoid disagreeing clusters, DEP ≫ IDENT.
  - ∗ Following Baković, I'll assume that palatalization is underlying (doesn't make any difference). I mark the IDENT violation caused by automatic pre-[i] palatalization with (*).

(43) Assimilation between adjacent disagreeing consonants

/at-bʲekʲtʲi/	AGREE[voi] AGREE[pal]	DEP(V)	IDENT[voi] IDENT[pal]
a. at-bʲekʲtʲi	*!		
b. ☞ adʲ-bʲekʲtʲi			**
c. atʲi-bʲekʲtʲi		*!	(*)

- When faithful concatenation of the input consonants would result in a sequence of identical consonants (i.e. prefix-final C = root-initial C), assimilation is not directly at stake. Here we observe epenthesis: NOGEM ≫ DEP(V).

(44) Epenthesis between adjacent identical consonants

/ap-putʲi/	AGREE[voi] AGREE[pal]	NOGEM	DEP(V)	IDENT[voi] IDENT[pal]
a. ap-putʲi		*!		
b. ab-putʲi	*!			*
c. ☞ apʲi-putʲi			*	(*)

- Crucially, if AGREE[voi] and AGREE[pal] dominate DEP(V), then the grammar will treat non-identical input C's which differ only in voicing and/or palatalization exactly the same as identical C's.
  - → They would have to assimilate if they were to surface next to each other (candidate (b)), so it's irrelevant that they were different in the input.

(45) Epenthesis, not assimilation, between near-identical consonants

/ap-bʲerʲtʲi/		AGREE[voi] AGREE[pal]	NOGEM	DEP(V)	IDENT[voi] IDENT[pal]
a.	ap-bʲerʲtʲi	*!			
b.	abʲ-bʲerʲtʲi		*!		**
c. ☞	apʲi-bʲerʲtʲi			*	(*)

- **Moral of the story:** OT can directly compare the result of assimilation to the result of epenthesis, and adjudicate between them via constraint ranking.
  - → If we were using rules, this would require a kind of look-ahead which is not possible in such a system.
    - ∗ The same critique can be (and has been) leveled at Harmonic Serialism (Adler & Zymet 2021).

4.3 The problem for rules

- If we try to implement the anti-gemination analysis in rules, we run into an ordering paradox.

(46) **Epenthesis rule with identity requirement:** $\varnothing \rightarrow i \,/\, C_\alpha\_C_\alpha$

- If Epenthesis > Assimilation, then concatenated consonants which are not underlyingly identical will not trigger epenthesis:

(47) Epenthesis > Assimilation: assimilation creates geminates (quasi–counter-feeding)

		/ap-bʲerʲtʲi/	
1.	**Epenthesis**	—	(← *environment not met yet*)
2.	**Assimilation**	abʲ-bʲerʲtʲi	(← *epenthesis environment met too late*)
		*[abʲ-bʲerʲtʲi]	

- On the other hand, if Assimilation > Epenthesis, the prefix C should exhibit the effects of assimilation:

(48) Assimilation > Epenthesis: assimilation across epenthetic vowel (feeding)

		/ap-bʲerʲtʲi/
1.	**Assimilation**	abʲ-bʲerʲtʲi
2.	**Epenthesis**	abʲi-bʲerʲtʲi
		*[abʲi-bʲerʲtʲi]

- No matter what, assimilation is going to apply, contrary to fact.

- If we simply have a general epenthesis rule, we won't be able to derive the difference between would-be geminates and (would-be) non-geminates.

(49) **General epenthesis rule:** Ø → i / C_C

(50) General Epenthesis > Assimilation: epenthesis incorrectly bleeds assimilation

		/ap-bʲerʲtʲi/	/at-bʲerʲtʲi/	
1.	**Epenthesis (gen.)**	apʲi-bʲerʲtʲi	atʲi-bʲerʲtʲi	(← *destroys environment for assimilation across the board*)
2.	**Assimilation**	—	—	(← *assimilation applies too late*)
		[apʲi-bʲerʲtʲi]	*[atʲi-bʲerʲtʲi]	

4.4 A brute-force fix

- There's a way to build the look-ahead into the rule-based system: write the rule with reference to place.

(51) Epenthesis rule w/ homorganicity requirement (Baković 2007:235, based on Odden 2005:113–115)
Ø → i / [-son,αplace]__[-son,αplace]

- If epenthesis applies to any sequence of homorganic stops, and it applies first, it will bleed assimilation and generate the correct results.

(52) Rule-ordering analysis: bleeding on environment (transparent interaction)

		/ap-bʲerʲtʲi/	
1.	**Epenthesis**	apʲi-bʲerʲtʲi	(← *destroys environment for assimilation*)
2.	**Assimilation**	—	(← *environment no longer met*)
		[apʲi-bʲerʲtʲi]	

- But Baković argues that this is missing the crucial generalization: epenthesis applies only in those sequences which would become geminates via assimilation.
- In more recent work, he argues at length that you can only have OCP-type constraints that refer to fully identical elements, not near identity.
  - → If he's right, we should not have access to the type of epenthesis rule required in order to avoid the ordering paradox; and therefore, there's a type of opaque interaction that OT actually does better on than rules.

5 One more opaque interaction type: self-destructive feeding in Turkish

- Turkish shows a weird type of overapplication opacity involving a process of velar deletion.

- Morpheme-final /k/ deletes before a vowel:

(53) **Velar deletion rule:** /k/ → Ø/ V_+V

- There are two rules where a preceding consonant is part of the environment:

(54) a. **Epenthesis rule:** Ø → i / C_C#
b. **Continuant deletion:** [+cont] → Ø/ C_

- Both of these rules **feed** velar deletion, as seen in (55), and also **counter-feed** velar deletion (56).

(55) Self-destructive feeding in Turkish (Baković 2007:226–227)

i. Epenthesis and velar deletion (Sprouse 1997)

		/bebek+n/	
1.	**Epenthesis:** Ø → i / C_C#	bebek+in	(cf. /ip+n/ → [ipin] 'your rope')
2.	**Velar deletion:** k → Ø/ V_+V	bebe+in	(cf. /bebek+i/ → [bebei] 'baby (acc)')
		[bebein]	'your baby' (not *[beben])

ii. Continuant deletion and velar deletion (Kenstowicz & Kisseberth 1979)

		/ajak+sɯ/	
1.	**Cont. deletion:** [+cont] → Ø/ C_	ajak+ɯ	(cf. /arɯ+sɯ/ → [arɯsɯ] 'his bee')
2.	**Velar deletion:** k → Ø/ V_+V	aja+ɯ	(cf. /ajak+ɯ/ → [ajaɯ] 'foot (acc)')
		[ajaɯ]	'his foot' (not *[ajasɯ])

(56) Reverse ordering counter-feeds velar deletion

i. Epenthesis and velar deletion

		/bebek+n/	
1.	**Velar deletion:** k → Ø/ V_+V	—	
2.	**Epenthesis:** Ø → i / C_C#	bebek+in	
		*[bebekin]	'your baby' (not *[bebein])

ii. Continuant deletion and velar deletion (Kenstowicz & Kisseberth 1979)

		/ajak+sɯ/	
1.	**Velar deletion:** k → Ø/ V_+V	—	
2.	**Cont. deletion:** [+cont] → Ø/ C_	ajak+ɯ	
		*[ajakɯ]	'his foot' (not [ajaɯ])

- Even though there's a feeding order, the result is not transparent: the epenthesis and continuant-deletion processes are non-surface-*apparent*, because the /k/ has also been deleted.

→ If you had known that the /k/ was going to delete, you would have never bothered to apply the first process in the first place: *[bebe-n] and *[aja-sɯ] would be perfectly well-formed, and significantly better than the actual result.

- No account using the velar deletion rule as currently formulated, and the inputs used here (both of which are up for debate), can derive the well-formed outputs (cf. (54)).

- These cases are often discussed in the context of phonologically-conditioned allomorphy.
  - They are used to argue that phonologically-conditioned allomorphy can be phonologically non-optimizing, but perhaps better to simply thing of it as opaque.

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