Formal Characterizations of True and False Sour Grapes

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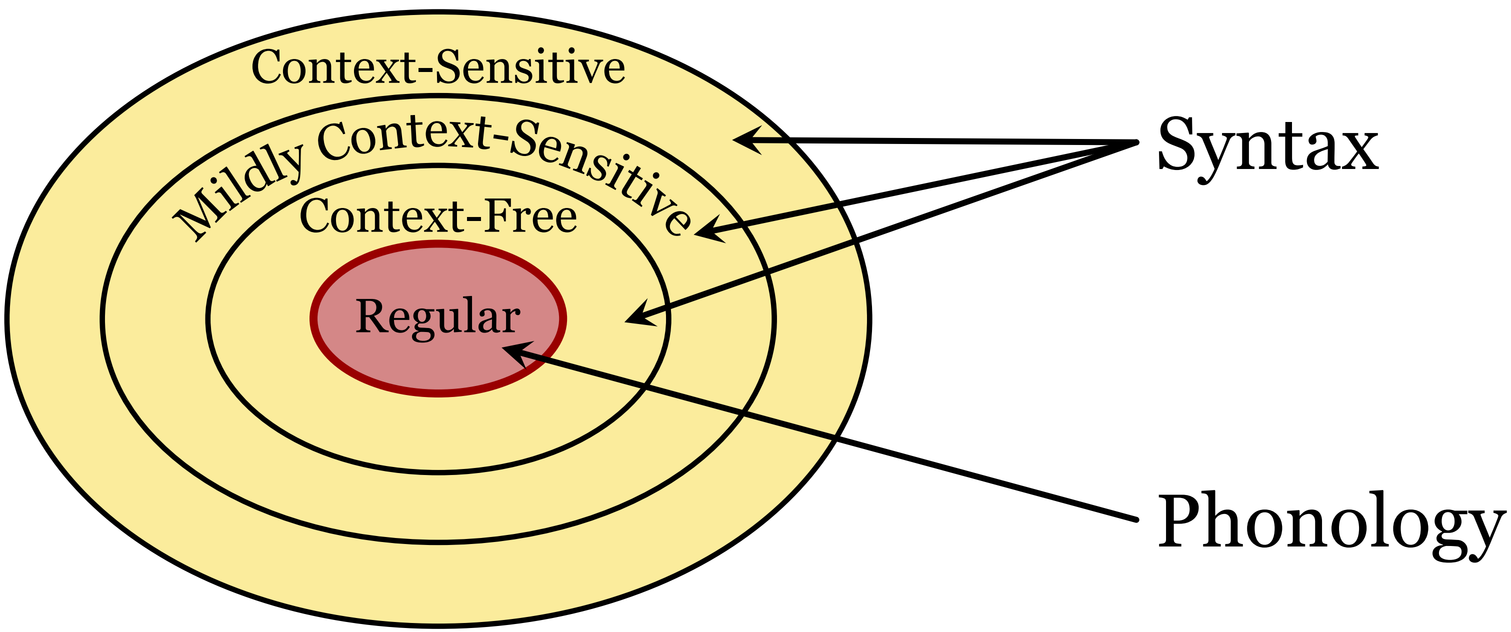
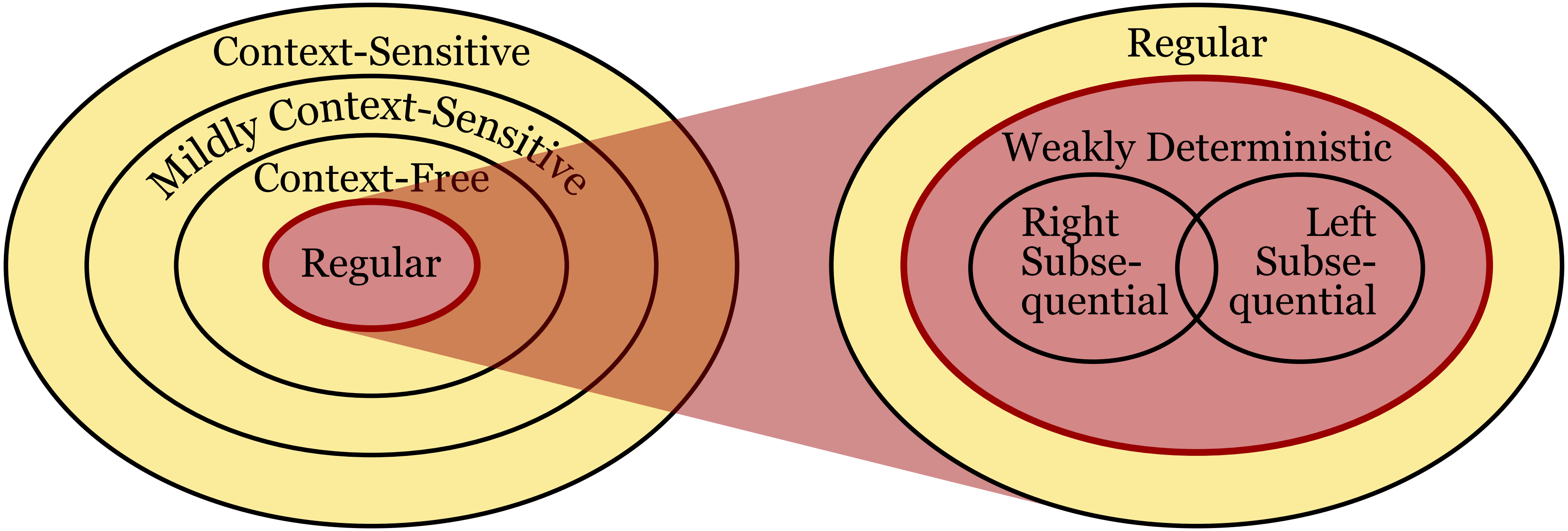
The Chomsky Hierarchy
(Chomsky 1956)

Input-output mappings can be classified by computational complexity:



The Subregular Hierarchy
(Heinz 2011)

Phonological mappings are a proper subset of regular input-output mappings:

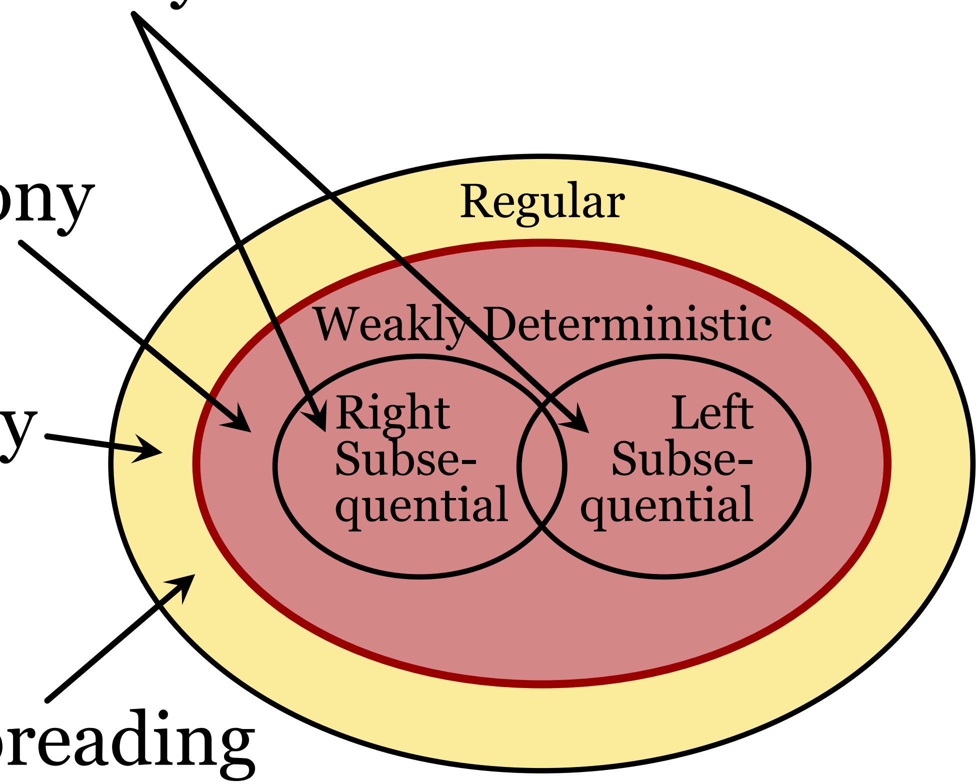


Weakly Deterministic Mappings
(Heinz & Lai 2013)

Unidirectional harmony

Bidirectional harmony

Sour Grapes pathology
(Wilson 2003)



Sour-grapes-like tone spreading
(Jardine 2016)

Our Proposals

Different sour-grapes-like patterns characterized by different degrees of computational complexity:

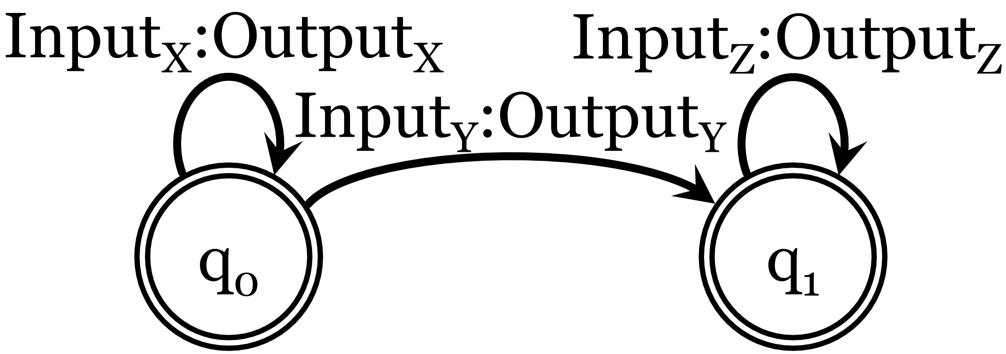
1) Attested **False Sour Grapes** patterns (e.g. Copperbelt Bemba tone spreading) are weakly deterministic (less complex)

2) Unattested **True Sour Grapes** patterns are regular, but not weakly deterministic (more complex)

Regular & Subregular Classifications

Finite State Transducers

- Regular input-output mapping of strings can be represented by finite state transducers
- Maps inputs to outputs by following transitions between states



- Finite state transducer indicates which input-output mappings are licit in a language

Subsequential Functions

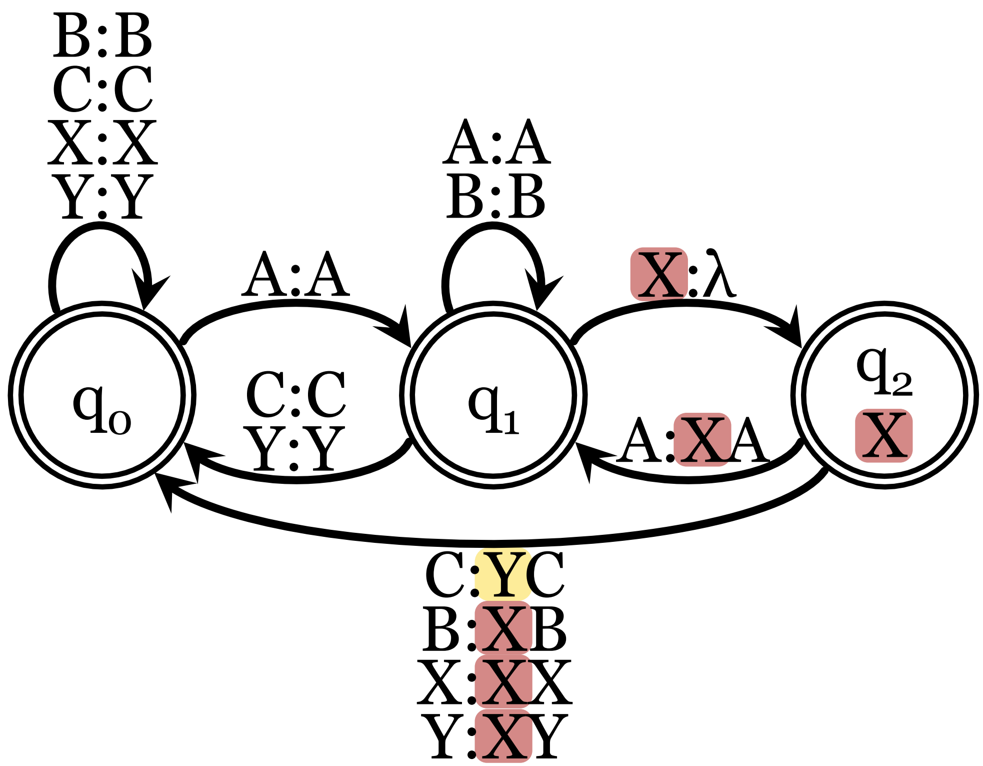
Subsequential functions: unbounded amount of material on only one side of the target

Left subsequential:

$X \longrightarrow Y / AB_0\_\_\_C$

Right subsequential:

$X \longrightarrow Y / C\_\_\_B_0A$



Regular & Weakly Deterministic Functions

- Regular mappings can be decomposed into left- and right-subsequential functions (Elgot & Mezei 1965)

- Weakly deterministic mappings (Heinz & Lai 2013) can be decomposed into left- and right-subsequential function that are:

  – Alphabet-preserving

  – Length-preserving

True Sour Grapes

True Sour Grapes Spreading
(Wilson 2003)

- Pathological pattern in which phonological property spreads to edge of domain or not at all
- Full spreading with no blocker present:

$$\mathrm{T\ U\ U\ U\ U\ \#} \longrightarrow \mathrm{T\ T\ T\ T\ T\ \#}$$

- No spreading with blocker present:

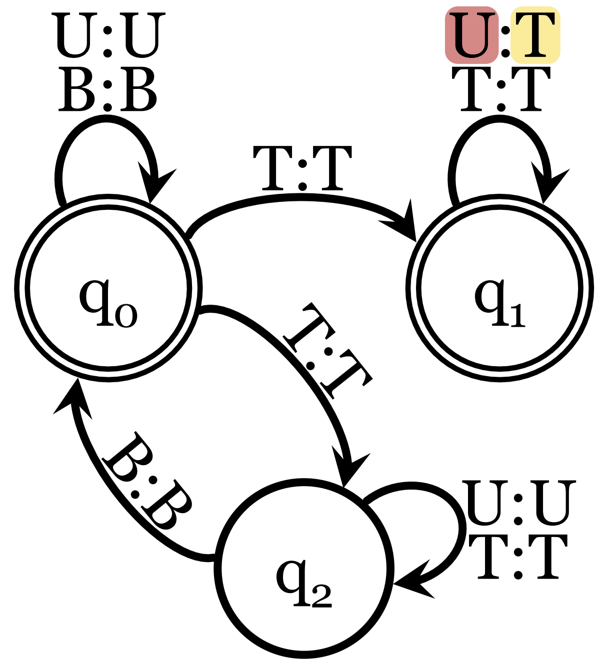
$$\mathrm{T\ U\ U\ B\ U\ \#} \longrightarrow \mathrm{T\ U\ U\ B\ U\ \#}$$

status as undergoers of harmony determined by material on both sides

True Sour Grapes Spreading

Regular rule:

$\mathrm{U} \longrightarrow \mathrm{T} / \mathrm{T}\{\mathrm{U},\mathrm{T}\}_0 \_\_ \{\mathrm{U},\mathrm{T}\}_0\#$



True Sour Grapes Decomposed

- True Sour Grapes can be decomposed into right and left subsequential functions

<u>Step 1: Right to Left</u>

a. $T \longrightarrow T_B / \_\_\{U,T\}_0 B$

b. $T \longrightarrow T_{\neg B} / \_\_\{U,T\}_0 \#$

<u>Step 2: Left to Right</u>

c. $U \longrightarrow T / T_{\neg B}\{U,T_{\neg B}\}_0 \_\_$

d. $T_{\neg B}, T_B \longrightarrow T / \_\_$

- Not weakly deterministic due to introduction of new intermediate symbols T_B and $T_{\neg B}$

False Sour Grapes: Copperbelt Bemba

Copperbelt Bemba Tone Spreading
(Bickmore & Kula 2013; Kula & Bickmore 2015; Jardine 2016)

Last high tone in a word spreads unboundedly to the right word edge:

H　　　　　　H H H H

/bá-ka-fik-a/ ⟶ [bá-ká-fík-á]

'they will arrive'

H　　　　　　L L H H H H

/tu-ka-páapaatik-a/ ⟶ [tù-kà-páápáátík-á]

'we will flatten'

Copperbelt Bemba Tone Spreading
(Bickmore & Kula 2013; Kula & Bickmore 2015; Jardine 2016)

If another high tone intervenes between a high tone and the end of the word:

- Unbounded spreading is blocked
- Ternary spreading occurs

H H H H H L H

/bá-ka-pat-a=kó/ ⟶ [bá-ká-pát-à=kó]

'they will hate a bit'

H H H H H L L L H

/bá-ka-londolol-a=kó/ ⟶ [bá-ká-lóndòlòl-à=kó]

'they will introduce them'

Copperbelt Bemba Tone Spreading

(Bickmore & Kula 2013; Kula & Bickmore 2015; Jardine 2016)

H H H H H L L L H

/bá-ka-londolol-a=kó/ ⟶ [bá-ká-lóndòlòl-à=kó]

status as undergoers of tone spreading determined by material on both sides

always undergoers of tone spreading

Predictability & Complexity

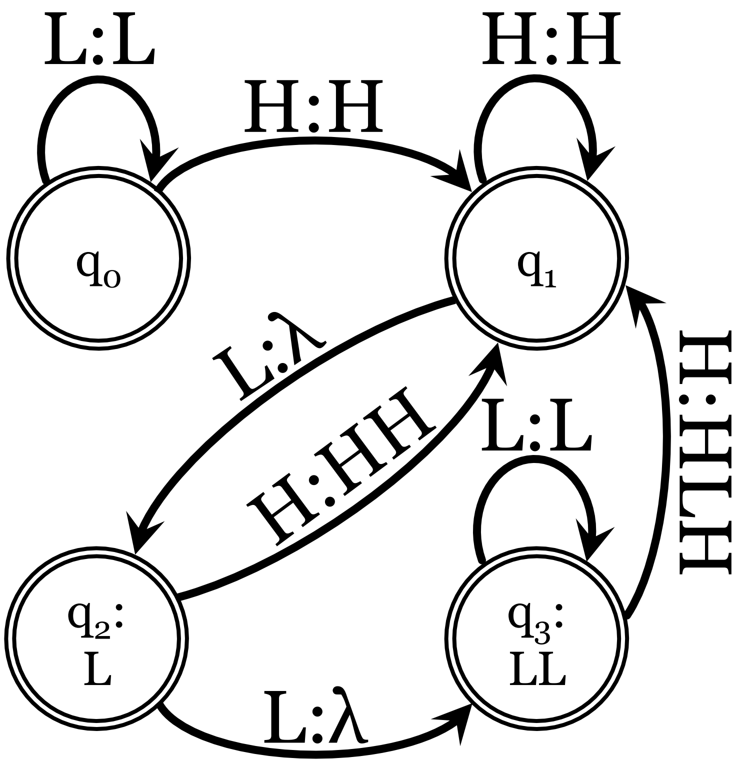
- Copperbelt Bemba: high tone spreading to two following tone bearing units provides a **predictable substring** that can be used to mark up successful and unsuccessful triggers of unbounded tone spreading

- **Zone of predictability:** predictable substring local to potential trigger of spreading that can be utilized for intermediate mark-up

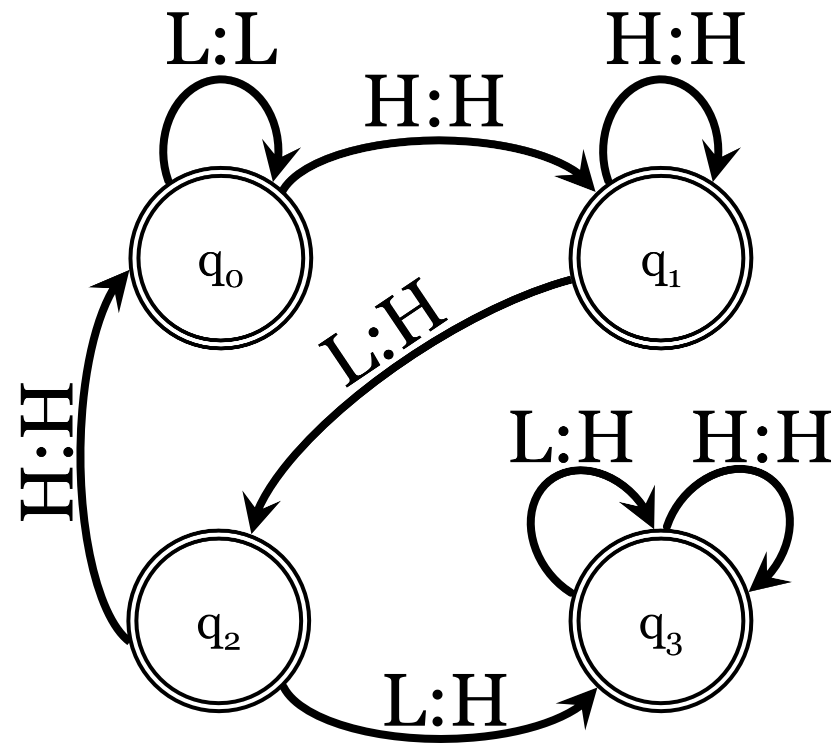
- See also Lamont (2019), McCollum et al (2018)

Copperbelt Bemba

Step 1: Right to Left



Step 2: Left to Right



Copperbelt Bemba

Step 1: Right to Left

a. $L \longrightarrow H / H\_\_H$

b. $L \longrightarrow H / HL\_\_L_{0}H$

Step 2: Left to Right

c. $L \longrightarrow H / HLL_{0}\_\_$

d. $L \longrightarrow H / HH\_\_H$

e. $L \longrightarrow H / LLH\_\_H$

f. $L \longrightarrow H / \#(L)H\_\_H$

Copperbelt Bemba Step 1 (Right to Left)

- Input HLH maps to intermediate HHH

Input	...H H H L_o #	... H L H L_o #
Intermediate	... H H H L_o #	... H L H L_o #

- Input HLL maps:
  - Faithfully to intermediate HLL when no other H follows
  - To intermediate HLH before another H

Input	...HLLL_o#	...HLLLLL_oH...	...HLHLLL_oH...	...HHHLLL_oH...
Intermediate	...HLLL_o#	...HLLLLL_oH...	...HLHLLL_oH...	...HHHLHL_oH...

- Result: intermediate HLH occurs if and only if another H follows, uniquely marking trigger of ternary spreading

Copperbelt Bemba Step 2 (Left to Right)

- Intermediate HLH maps to output HHH, but does not spread H any further

Input	… H L L L_o H …	… H L H L L L_o H …	…H H H L L L_o H …
Intermediate	… H L L L_o H …	… H L H L L L_o H …	… H H H L H L_o H …
Output	… H H H H_o H	… H H H (L L) L_o H …	… H H H H H L_o H …

- Intermediate HLL maps to output HHH and spread H unboundedly to right edge of word

Input	… H L L L_o #	… H L H L_o #	…H H H L_o #
Intermediate	… H L L L_o #	… H L H L_o #	… H H H L_o #
Output	… H H H H_o #	… H H H L_o #	

Revisiting True Sour Grapes

Revisiting True Sour Grapes

- No **zone of predictability** local to potential triggers of harmony
- Neutralization when no blocker is present

$T\ U\ U\ U_o\ \#$ $\qquad$ $T\ T\ U\ U_o\ \#$ $\qquad$ $T\ T\ T\ U_o\ \#$

$T\ U\ U\ U_o\ \#$ $\qquad$ $T\ T\ U\ U_o\#$ $\qquad$ $T\ T\ T\ T_o\ \#$

- No neutralization when blocker is present

$T\ U\ U\ U_o\ B$ $\qquad$ $T\ T\ U\ U_o\ B$ $\qquad$ $T\ T\ T\ U_o\ B$

$\downarrow \qquad\qquad \downarrow \qquad\qquad \downarrow$

$T\ U\ U\ U_o\ B$ $\qquad$ $T\ T\ U\ U_o\ B$ $\qquad$ $T\ T\ T\ U_o\ B$

Revisiting True Sour Grapes

Substring markup strategy: identify substring MMM that can uniquely represent unsuccessful trigger intermediately

Input	TUUU$_o$#	TUUU$_o$B…	
Intermediate	TUUU$_o$#	TUUU$_o$B…	MMMU$_o$B…
Output	TTTT$_o$#	TUUU$_o$B…	

Revisiting True Sour Grapes

- All substrings surface faithfully before a blocker
- Result: substring MMM cannot be used to uniquely mark up an unsuccessful trigger

Input	TUUU$_o$#	TUUU$_o$B…	MMMU$_o$B…
Intermediate	TUUU$_o$#	TUUU$_o$B…	MMMU$_o$B…
Output	TTTT$_o$#	TUUU$_o$B…	MMMU$_o$B…

Revisiting True Sour Grapes

- Substring mark-up strategy cannot be applied to cases of True Sour Grapes
- Result: unattested True Sour Grapes cannot be represented by a weakly deterministic input-output mapping

Conclusion

Conclusion

- Sour-grapes-like patterns of spreading are only attested if they involve zones of predictability, rendering their mappings weakly deterministic
- Attested False Sour Grapes spreading patterns are weakly deterministic
- Unattested True Sour Grapes spreading is regular, but not weakly deterministic

Remaining Questions

- How do zones of predictability affect computational complexity of other phonological processes?
- How do zones of predictability relate to information theoretic notions of data compression?
- Is predictability a different type of complexity than the formal complexity of mappings?

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