Gradient Symbolic Representations and the Typology of Phonological Exceptions

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Main Claim

- The assumption of Gradient Symbolic Representations that phonological elements can have different **degrees of activation** allows a unified explanation for patterns of exceptions.
- This **representational** explanation for different phonological behaviour dispenses with true ‘exceptionality’: A single phonological grammar and contrasting underlying representations.
- Four predictions set this account apart from alternatives:
  - ① Unified account for (non)undergoers and (non)triggers.
  - ② Exceptionality for more than one process.
  - ③ Degrees of exceptionality.
  - ④ Implicational restrictions between exceptionality patterns.

Plan

Proposal

Gradient Symbolic Representation in Input/Output (=GSRO)

- all linguistic symbols have **activity** that can **gradiently** differ and 1 is the default activity (Smolensky and Goldrick, 2016; Rosen, 2016)
- any change in activity is a faithfulness violation – different activities result in **gradient violations of faithfulness**
- elements can be gradiently active in the output and thus violate **markedness constraints gradiently**

  (Zimmermann, 2017*a*,*b*; Faust and Smolensky, 2017; Jang, 2019; Walker, 2019)
- grammatical computation modeled inside **Harmonic Grammar** where constraints are weighted (Legendre et al., 1990; Potts et al., 2010)

GSRO: Gradient Constraint Violations

- constraints are **violated/satisfied relative to the activity** of the relevant elements
- elements preferably have the default activity of 1 (=*Weak, *Strong)
- e.g. the underlyingly weakly active segment in (1)
  - is **easier to delete** than a fully active segment
  - is **costly to realize**
  - **tolerates more marked structures**

(1) Gradient activity=gradient constraint violations

$b_1a_1t_1$-$p_{0.5}$	*Weak	MaxS	DepS	*CC		
	10	10	10	10		
a. $b_1a_1t_1p_1$			**-0.5**	**-1**	-15	Only fully active S
b. $b_1a_1t_1p_{0.5}$	**-0.5**			**-0.75**	-12.5	Faithful realization of weak S
c. $b_1a_1p_{0.5}$	**-0.5**	**-1**			-15	Deletion of fully active S
☞ d. $b_1a_1t_1$		**-0.5**			-5	Deletion of weakly active S

GSRO and Exceptions

- if the underlying representation of a morpheme contains elements of another activity than the default activity 1, the morphemes might show **different phonological behaviour**

→ 'exceptions' = **contrastive underlying representations**

Gradient Symbolic Representations: Broader Context

- that linguistic elements are not categorical but have strength differences is **not a new** idea

  (e.g. Rizzi (1986) and Koster (1986) for functional categories in syntax, Garde (1965): some lexical accent system are based on scalar grades of accent strength,...)

- other work on non-categorical elements in **neural networks**

  (e.g. Corina (1994) on induction of prosodic categories in neural networks)

- can also predict **phonetic gradience**

  (e.g. subphonemic gradience in word-final devoicing, nasal place assimilation, flapping (e.g. Braver, 2013), vowel harmony is gradient (McCollum, 2018),...)

- **different from a binary** distinction into strong/weak

  (Inkelas, 2015; Vaxman, 2016*a*,*b*; Sande, 2017)

➙ here: predictions of **gradient (=numerical) phonological strength in an OT-system** as explanation for 'exceptional' behaviour

General Arguments for GSR(O)

1. Embedded in a general **computational architecture for cognition** (=Gradient Symbolic Computation, Smolensky and Goldrick, 2016)
2. A **unified account** for different exceptional phonological behaviours:
   - liaison consonants in French (Smolensky and Goldrick, 2016)
   - semi-regularity of voicing in Japanese Rendaku (Rosen, 2016)
   - allomorphy in Modern Hebrew (Faust and Smolensky, 2017)
   - lexical accent in Lithuanian (Kushnir, 2017)
   - tone sandhi in Oku (Nformi and Worbs, 2017)
   - tone allomorphy in San Miguel el Grande Mixtec (Zimmermann, 2017*a*,*b*)
   - lexical stress in Moses Columbian Salishan (Zimmermann, 2018*d*)
   - exceptional tone (non)spreading in San Molinos Mixtec (Zimmermann, 2018*b*)
   - interaction of phonological/lexical gemination/lenition in Italian (Amato, 2018)
   - compound stress in Sino-Japanese (Rosen, 2018)
   - (interacting) ghost segments in Welsh (Zimmermann, 2018*c*)
   - …

GSRO: Four Predictions = Four Arguments

① A unified account for exceptional (non)undergoers and (non)triggers.

② Elements can be exceptional for more than one process.

③ There can be different degrees of exceptionality (for the same process within a language).

④ Exceptionality patterns within one language underlie implicational restrictions.

Types of Exceptions: Toy Example

(Classification into undergoers/triggers from Lakoff (1970))

A general phonological rule in Lg1: Parasitic Backness Vowel Harmony

pon–ek → ponok *VH if same height*

put–ek → putek *No VH if different height*

1. Exceptional non-undergoer

Same height: No VH

pon– et → ponet, *ponot

2. Exceptional non-trigger

Same height: No VH

ton –ek → tonek, *tonok

3. Exceptional undergoer

Different height: VH

put– em → putom, *putem

4. Exceptional trigger

Different height: VH

put –ek → putok, *putek

① Unified Account for Exceptional (Non)Undergoers and (Non)Triggers: Our Toy Example

(2) a. MAX[BK]
Assign -X violation for every input feature $[\text{back}]_X$ without an output correspondent.

b. SH[BK]
Assign -X violation for every pair of tier-adjacent vowels V_A and V_B with different [±back] specifications where -X is the mean activity $\frac{A+B}{2}$.

c. $\text{SH[BK]}_{\text{HI}}$
Assign -X violation for every pair of tier-adjacent vowels V_A and V_B with the same specification for [±high] but different [±back] specifications where -X is the mean activity $\frac{A+B}{2}$.

Toy Example: Four Patterns of Exceptionality in GSRO

(3) ‘Regular’: No VH if diff. height

$p_1u_1t_1$–e_1k_1	Max[bk] 15	Sh[bk]$_{\text{HI}}$ 10	Sh[bk] 10	
☞ a. $p_1u_1t_1e_1k_1$			-1	-10
b. $p_1u_1t_1o_1k_1$	-1			-15

(4) ‘Regular’: VH if same height

$p_1o_1n_1$–e_1k_1	Max[bk] 15	Sh[bk]$_{\text{HI}}$ 10	Sh[bk] 10	
a. $p_1o_1n_1e_1k_1$		-1	-1	-20
☞ b. $p_1o_1n_1o_1k_1$	-1			-15

Toy Example: Four Patterns of Exceptionality in GSRO

(5) Exceptional trigger:
Stronger stem-vowel enforces VH even if different height

$k_1u_3n_1$ –e_1k_1	Max[bk] 15	Sh[bk]$_{\text{hi}}$ 10	Sh[bk] 10	
a. $k_1u_3n_1e_1k_1$			**-2**	-20
☞ b. $k_1u_3n_1o_1k_1$	-1			-15

(6) Exceptional non-trigger:
Weaker stem-vowel doesn’t enforce VH even if same height

$t_1o_{0.4}n_1$ –e_1k_1	Max[bk] 15	Sh[bk]$_{\text{hi}}$ 10	Sh[bk] 10	
☞ a. $k_1o_{0.4}l_1e_1k_1$		**-0.7**	**-0.7**	-14
b. $k_1o_{0.4}l_1o_1k_1$	-1			-15

Toy Example: Four Patterns of Exceptionality in GSRO

(7) Exceptional undergoer:
Weaker affix-vowel[1]undergoes VH even if different height

$p_1u_1t_1$– $e_{0.4}m_1$	Max[bk] 15	Sh[bk]$_{HI}$ 10	Sh[bk] 10	
a. $p_1u_1t_1e_{0.4}m_1$			0.7	-7
☞ b. $p_1u_1t_1o_{0.4}m_1$	**-0.4**			-6

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[1] Abbreviation: The feature [-back] is weak, not the segment.

(8) Exceptional non-undergoer:
Stronger affix-vowel resists VH even if same height

$p_1o_1n_1$– e_3t_1	Max[bk] 15	Sh[bk]$_{HI}$ 10	Sh[bk] 10	
☞ a. $p_1o_1n_1e_3t_1$		-2	-2	-40
b. $p_1o_1n_1e_3t_1$	**-3**			-45

Four Patterns of Exceptionality and GSRO: Summary

$E_{1\text{-}x}$ – being weaker than the 'default' element E_1

- exceptional undergoer – since not as protected by faithfulness as E_1
- exceptional non-undergoer – since not inducing as much markedness violation as E_1
- exceptional non-trigger – since not inducing as much markedness violation as E_1

E_{1+x} – being stronger than the 'default' element E_1

- exceptional undergoer – since inducing more markedness violation than E_1
- exceptional non-undergoer – since protected more by faithfulness as E_1
- exceptional trigger – since inducing more markedness violation than E_1

Four Patterns of Exceptionality: Empirical Picture

1. Exceptional non-undergoers

- some M-tones resist to undergo a dissimilation into H in Kagwe (Hyman, 2010)
- some moras are non-hosts for floating tones in San Miguel el Grande Mixtec (Pike, 1944; McKendry, 2013)
- …

2. Exceptional non-triggers

- some vowels do not trigger otherwise regular ATR-harmony in Classical Manchu (Smith, 2017)
- some H-tones in Molinos Mixtec don't undergo H-spreading (Hunter and Pike, 1969)
- …

3. Exceptional undergoers

- only some vowels undergo V-harmony in Y. Mayan (Krämer, 2003)
- only some segments are deleted to avoid a marked structure in, e.g., Nuuchahnulth or Yawelmani (Noske, 1985; Zoll, 1996)
- …

4. Exceptional triggers

- some suffixes trigger deletion of a preceding V in Yine (Pater, 2010)
- some suffixes trigger raising of a preceding low V in Assamese (Mahanta, 2012)
- …

② Exceptionality for More than one Process: Extending our Toy Example

A general phonological rule in Lg2: Parasitic Backness Vowel Harmony

po–nek	→ ponok	*VH if same height*
pu–nek	→ punek	*No VH if different height*

Another general phonological rule in Lg2: Vowel hiatus avoidance

pu–ok	→ pok	*Deletion of first V*

1. Exceptional trigger for VH

Different height: VH

ku–nek → kunok, *kunek

2. Exceptional non-undergoer of VD

Vowel hiatus: No deletion

ku–ok → kuok, *kok

Exceptionality for More than one Process: GSRO

(9) ‘Regular’: No VH if diff. height

p_1u_1–$n_1e_1k_1$	*VV 28	MaxS 20	Max[bk] 15	Sh[bk]$_{HI}$ 10	Sh[bk] 10	
☞ a. $p_1u_1n_1e_1k_1$					-1	-10
b. $p_1u_1n_1o_1k_1$			-1			-15

(10) Exceptional trigger:
Stronger stem-vowel enforces VH even if different height

k_1u_3 –$n_1e_1k_1$	*VV 28	MaxS 20	Max[bk] 15	Sh[bk]$_{HI}$ 10	Sh[bk] 10	
a. $k_1u_3n_1e_1k_1$					**-2**	-20
☞ b. $k_1u_3n_1o_1k_1$			-1			-15

Exceptionality for More than one Process: GSRO

(11) ‘Regular’: VD to avoid hiatus

p_1u_1–o_1k_1	*VV	MaxS	Max[bk]	Sh[bk]$_{\text{hi}}$	Sh[bk]	
	28	20	15	10	10	
a. $p_1u_1o_1k_1$	-1					-28
☞ b. $p_1o_1k_1$		-1				-20

(12) Exceptional non-undergoer:
Stronger stem-vowel resists VD

k_1u_3–o_1k_1	*VV	MaxS	Max[bk]	Sh[bk]$_{\text{hi}}$	Sh[bk]	
	28	20	15	10	10	
☞ a. $k_1u_3o_1k_1$	-2					-56
b. $k_1o_1k_1$		**-3**				-60

Exceptionality for More than one Process: GSRO

(13) Exceptional trigger:
Stronger stem-vowel enforces VH even if different height

k_1u_3 –$n_1e_1k_1$	*VV 28	MaxS 20	Max[bk] 15	Sh[bk]$_{hi}$ 10	Sh[bk] 10	
a. $k_1u_3n_1e_1k_1$					**-2**	-20
☞ b. $k_1u_3n_1o_1k_1$			-1			-15

(14) Exceptional non-undergoer:
Stronger stem-vowel resists VD

k_1u_3 –o_1k_1	*VV 28	MaxS 20	Max[bk] 15	Sh[bk]$_{hi}$ 10	Sh[bk] 10	
☞ a. $k_1u_3o_1k_1$	-2					-56
b. $k_1o_1k_1$		**-3**				-60

→ The **same representation** /k_1u_3/ predicts **exceptional behaviour for more than one process** from different gradient constraint violations

③ Degrees of Exceptionality: A new toy example

Lg3 without backness harmony

pok–el → pokel *No parasitic VH*

pok–im → mutel *No non-parasitic VH*

Exceptional trigger I

tom –el → tomol, *tomel *Triggers parasitic VH*

tom –im → tomim, *tomum *Does not trigger non-parasitic VH*

Exceptional trigger II

sop –el → sopol, *sopel *Triggers parasitic VH*

sop –im → sopul, *supim *Triggers non-parasitic VH*

Degrees of Exceptionality: GSRO

(15) ‘Regular’: No VH if diff. height

$p_1o_1k_1–i_1m_1$	MAX[BK] 25	SH[BK]$_{\text{HI}}$ 10	SH[BK] 10	
☞ a. $p_1o_1k_1i_1m_1$			-1	-10
b. $p_1o_1k_1u_1m_1$	-1			-25

(16) ‘Regular’: No VH if same height

$p_1o_1k_1–e_1l_1$	MAX[BK] 25	SH[BK]$_{\text{HI}}$ 10	SH[BK] 10	
☞ a. $p_1o_1k_1e_1l_1$		-1	-1	-20
b. $p_1o_1k_1o_1l_1$	-1			-25

Degrees of Exceptionality: GSRO

(17) Exceptional trigger I: No VH if diff. height

$t_1o_3m_1$ –i_1m_1	Max[bk] 25	Sh[bk]$_{HI}$ 10	Sh[bk] 10	
☞ a. $t_1o_3m_1i_1m_1$			**-2**	-20
b. $t_1o_3m_1u_1m_1$	-1			-25

(18) Exceptional trigger I: VH if same height

$t_1o_3m_1$ –e_1l_1	Max[bk] 25	Sh[bk]$_{HI}$ 10	Sh[bk] 10	
a. $t_1o_3m_1e_1l_1$		**-2**	**-2**	-40
☞ b. $t_1o_3m_1o_1l_1$	-1			-25

Degrees of Exceptionality: GSRO

(19) Exceptional trigger II: VH if diff. height

$s_1o_5p_1$–i_1m_1	Max[bk]	Sh[bk]$_{\text{HI}}$	Sh[bk]	
	25	10	10	
a. $s_1o_5p_1i_1m_1$			**-3**	-30
☞ b. $s_1o_5p_1u_1m_1$	-1			-25

(20) Exceptional trigger II: VH if same height

$s_1o_5p_1$–e_1l_1	Max[bk]	Sh[bk]$_{\text{HI}}$	Sh[bk]	
	25	10	10	
a. $s_1o_5p_1e_1l_1$		**-3**	**-3**	-60
☞ b. $s_1o_5p_1o_1l_1$	-1			-25

④ Implicational Relations

- if all exceptionality results from differences in activity of phonological elements, not all imaginable combinations of exceptionality patterns in a language are possible: **Certain exceptionality patterns imply each other**

Thresholds for Exceptionality

E_{1+x+y} ➙ Exceptional Behaviour X+Y

STRONGER: THRESHOLD 2

E_{1+x} ➙ Exceptional Behaviour X

STRONGER: THRESHOLD 1

E_{1} ➙ ‘Normal’ Behaviour

WEAKER: THRESHOLD 1

E_{1-v} ➙ Exceptional Behaviour V

WEAKER: THRESHOLD 1

E_{1-v-w} ➙ Exceptional Behaviour W

Implicational Relations between Exceptionality Patterns

(21) If a language L has

a. (a) morpheme(s) that is/are exceptional$_1$ for process P1

b. and (a) morpheme(s) that is/are exceptional$_1$ for process P1 and exceptional$_2$ for process P2

c. there cannot be (a) morpheme(s) that is/are exceptional$_2$ for process P2 but not exceptional$_1$ for process P1

Implicational Relations: Yet Another Toy Example

Language 4 with parasitic VH and hiatus avoidance

po–nek	→ ponok	*VH if same height*
pu–nek	→ punek	*No VH if different height*
pu–ok	→ pok	*Deletion of first V*

1. Exceptional trigger for VH

ku–nek	→ kunok, *kunek	*VH if different height*

2. Exceptional non-undergoer of VD and trigger for VH

pu–ok	→ puok, *pok	*No V-deletion to avoid hiatus*
pu–nek	→ punok, *punek	*VH if different height*

3. Exceptional non-undergoer of VD

tu–ok	→ tuok, *tok	*Deletion of first V*
tu–nek	→ tunek, *tunok	*No VH if different height*

Language 4 is Impossible in GSRO

(22) Normal: V with activity 1

a. Max[bk] > Sh[bk] *No non-parasitic VH*
b. *Hiat > MaxS *VD*

(23) Exceptional 1: V with activity X

a. X×Sh[bk] > Max[bk] *Non-parasitic VH*
b. *Hiat > X×MaxS *VD*

(24) Exceptional 2: V with activity Y

a. Y×Sh[bk] > Max[bk] *Non-parasitic VH*
b. Y×MaxS > *Hiat *No VD*

(25) *Exceptional 3: V with activity Z

a. Max[bk] > Z×Sh[bk] *No non-parasitic VH*
b. Z×MaxS > *Hiat *No VD*

➙ **Weighting paradox** (Z < X and Z > X; (23) vs. (25))

Case study 1: Exceptionality in San Pedro Molinos

Exceptional Non-Triggers in San Pedro Molinos

- some morphemes are exceptional (optional) non-triggers of H-perturbation and exceptional non-trigger of H-spreading

  ➙ **prediction ① existence of exceptional non-triggers**

  ➙ **prediction ② exceptionality for more than one process**

Background: Tones in San Pedro Molinos (=MOL)

- all the data in the following comes from Hunter and Pike (1969)
  variety closely related to San Miguel el Grande Mixtec (Cf. Pike (1944); Mak (1950); Hollenbach (2003); McKendry (2013); theoretical accounts in Goldsmith (1990); Tranel (1995); Zimmermann (2018*a*))
- three level tones high (H; á), mid (M; ā), and low (L; à)

(26) Tonal contrasts in MOL (Hunter and Pike, 1969, 27)

tātá-ą́	tūtą̄-są́	tūtù-są́
'my father'	'my firewood'	'my paper'
ʔùù ríkī	ʔùù kītī	ʔùù híī
'two woodpeckers'	'two animals'	'two fists'

Process 1: H-Perturbation

- some morphemes trigger an **additional H** that overwrites underlying M or L of the initial TBU of a following morpheme
  (the 'perturbing' morphemes found in basically all Otomanguean languages (Dürr, 1987; Pike, 1944; Mak, 1950; Hollenbach, 2003; McKendry, 2013))

(27) H-overwriting

$$\mathbf{XX}^{\mathbf{H}}\ \mathrm{XX} \rightarrow \mathrm{XX}\ \mathbf{H}\mathrm{X}$$

Process 1: H-Perturbation

(28) (Hunter and Pike, 1969, 35-36)

	M1	M2	Surface	Tones
Non-perturbing morphemes				
a.	ʔùʃì	rīŋkī	ʔùʃì rīŋkī	LL MM→LL MM
	‘ten’	‘mouse’	‘ten mice’	
b.	ʔḭ̄ḭ̄	**sùʧī**^{H}	ʔḭ̄ḭ̄ sùʧī	MM+LM^{H}→MM LM
	‘one’	‘child’	‘one child’	
Perturbing morphemes				
c.	**kṵ̀ṵ̀**^{H}	ʧìká	kṵ̀ṵ̀ ʧ**í**ká	LL^{H} LH→LL **H**H
	‘four’	‘baskets’	‘four baskets’	
d.	**ʒāʔā**^{H}	ʒìʧí	ʒāʔā ʒ**í**ʧí	MM^{H} LH→MM **H**H
	‘chiles’	‘dry’	‘dry chiles’	
e.	**síví**^{H}	tèē	síví t**é**ē	HH^{H} LM→HH **H**M
	‘name’	‘man’	‘name of the man’	
f.	**kītī**^{H}	kūù	kītī k**ú**ù	MM^{H} ML→MM **H**L
	‘animal’	‘to die’	‘the animal will die’	

Process 2: H-Spreading after Perturbation

- if a perturbing morpheme precedes a morpheme that ends in an M-toned TBU and is also perturbing, both TBU's of this morpheme become high

(29) H-overwriting and spreading

$$\mathbf{XX^{H}\ XM^{H}} \rightarrow \mathrm{XX}\ \mathbf{HH}$$

Process 2: H-Spreading after Perturbation

(30) (Hunter and Pike, 1969, 35-36)

	M1	M2	Surface	Tones
H-overwriting and spreading				
a.	**síví**^{H}	**sùʧī**^{H}	síví s**ú**ʧ**í**	HH^{H}+LM^{H}→HH **HH**
	‘name’	‘child’	‘name of the child’	
b.	**síví**^{H}	**kītī**^{H}	síví k**í**t**í**	HH^{H}+MM^{H}→HH **HH**
	‘name’	‘animal’	‘name of the animal’	
c.	**kītī**^{H}	**kāā**^{H}	kītī k**áá**	MM^{H}+MM^{H}→MM **HH**
	‘animal’	‘to eat’	‘the animal will eat’	
No spreading if M2 is not M-final				
d.	**kṵ̀ṵ̀**^{H}	**ʒòò**^{H}	kṵ̀ṵ̀ ʒ**ó**ò	LL^{H}+LL^{H}→LL **H**L
	‘four’	‘mont(H)’	‘four months’	
No spreading if M2 has no floating H				
e.	**síví**^{H}	tèē	síví t**é**ē	HH^{H}+LM→HH **H**M
	‘name’	‘man’	‘name of the man’	

Optionally Perturbing Morphemes as Exceptions

- there are three classes of morphemes in MOL:

  1. non-perturbing ones: XX
  2. perturbing ones: **$\mathbf{XX^{H}}$**
     - trigger H-perturbation
     - trigger H-spreading if they end in an M
  3. **optionally perturbing** ones: **$\mathbf{XX^{(H)}}$**
     - only optionally trigger H-perturbation
     - never trigger H-spreading if they end in an M

  ➙ not optional variation between behaving as morpheme type 1 and 2 but mixture of properties

Optionally Perturbing Morphemes: 1. Optional H-Perturbation

(31) (Hunter and Pike, 1969, 35-36)

	M1	M2	Surface	Tones
a.	**hìkī**$^{\mathbf{(H)}}$ ‘fist, paw’	tèē ‘man’	hìkī t**é**ē∼tèē ‘the man’s fist’	LM$^{(H)}$+LM→LM **H**M∼LM
b.	**hìkī**$^{\mathbf{(H)}}$ ‘fist, paw’	ʧį̀ʔį̄ ‘skunk’	hìkī ʧ**į́**ʔį̄∼ʧį̀ʔį̄ ‘the skunk’s paw’	LM$^{(H)}$+LM→LM **H**M∼LM
c.	**ñùtī**$^{\mathbf{(H)}}$ ‘sand’	ʒìʧí ‘dry’	ñùtī ʒ**í**ʧí∼ʒìʧí ‘dry sand’	LM$^{(H)}$+LH→LM **H**H∼LH

Optionally Perturbing Morphemes: 2. No Trigger for H-Spreading

(32) (Hunter and Pike, 1969, 36)

	M1	M2	Surface	Tones
Never a trigger…				
a.	**sívi**$^{\textbf{H}}$ 'name'	**ʧį̀ʔį̄**$^{\textbf{(H)}}$ 'skunk'	síví ʧį́ʔį̄ 'name of the skunk'	HH$^{\text{H}}$+LM$^{\text{(H)}}$→HH **H**M
b.	**hìkī**$^{\textbf{(H)}}$ 'fist, paw'	**ʧį̀ʔį̄**$^{\textbf{(H)}}$ 'skunk'	hìkī ʧį́ʔį̄∼ʧį̀ʔį̄ 'the skunk's paw'	LM$^{\text{(H)}}$+LM$^{\text{(H)}}$→LM **H**M∼LM
…but always an undergoer (if realized)				
c.	**ʧį̀ʔį̄**$^{\textbf{(H)}}$ 'skunk'	**kāā**$^{\textbf{H}}$ 'to eat'	ʧį̀ʔį̄ k**áá**∼kāā 'the skunk will eat (it)'	LM$^{\text{(H)}}$+MM$^{\text{H}}$→LM **HH**∼MM
d.	**hìkī**$^{\textbf{(H)}}$ 'fist'	**sùʧī**$^{\textbf{H}}$ 'child'	hìkī s**ú**ʧ**í**∼sùʧī 'the child's fist'	LM$^{\text{(H)}}$+LM$^{\text{H}}$→LM **HH**∼LM

GSRO Account: Representational Assumption

- Some morphemes in MOL end in an **unassociated (=floating) H-tone**
- The floating H of some morphemes is **fully active**: H_1
- The floating H of other morphemes is **partially active**: $H_{0.4}$
    - the weakly active $H_{0.4}$ is not a bad enough problem for *FLOAT and is not always associated
    - the weakly active $H_{0.4}$ is not a bad enough problem for the markedness constraint *[MH] triggering H-spreading

Additional Assumption: Variation and MaxEnt

- optionality is modeled with MaxEnt
  (Johnson, 2002; Goldwater and Johnson, 2003; Wilson, 2006)

→ both cases studies happen to involve optional variation – but this optionality is in principle orthogonal to the assumption of gradient activity!

- all exemplary weights given are calculated by the UCLA Maxent Grammar Tool (Hayes, 2009)

GSRO Account: Constraints (Yip, 2002)

(33) a. *Float

Assign -X violation for every tone T_1 that is not associated to a TBU where X is the activity of T_1.

b. MaxT

Assign -X violation for any tonal activity X in the input that is not present in the output.

c. *Cont

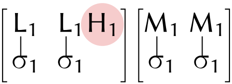
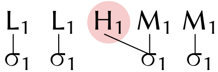
Assign -X violation for every TBU_1 associated to tones T_2 and T_3 where X is the shared activity of TBU_1, T_2, and T_3.

d. Spec

Assign -1-X violations for every TBU τ_1 where X is the activity of tone(s) associated to τ_1.

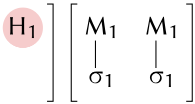
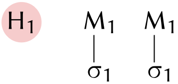
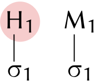
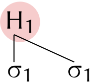
H-Perturbation: Realization of H_1

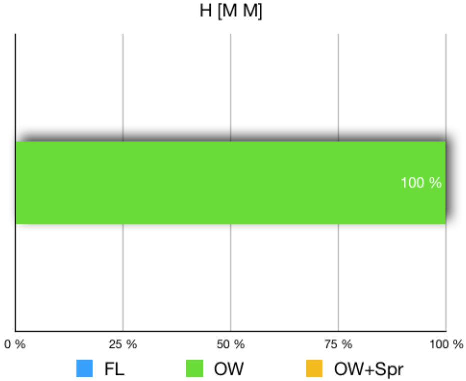
(34)

		MaxH	*Cont	*Float	MaxT	Spec	
		100	100	71	24	8	
a.				-1			-71
b.		-1			-1		-124
c.			-1				-100
☞ d.					-1		-24

MOL: Fully active H_1 is realized: Maxent probabilities

(35)

	*H*	Probability
a. 	-71,0	4,20E-21
☞ b. 	-24,08	0,9999
c. 	-48,16	3,49E-11



H-Perturbation: Optional Realization of $H_{0.4}$

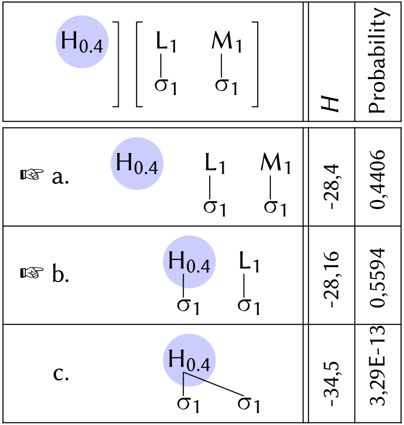
(36)

$[L_1\ M H_{0.4}]\ [L_1\ M_1]$ $\sigma_1\ \sigma_1\ \ \sigma_1\ \sigma_1$	MaxH	*Cont	*Float	MaxT	Spec	
	100	100	71	24	7	
☞ a. $L_1\ M\ H_{0.4}\ L_1\ M_1$ $\sigma_1\ \sigma_1\ \ \sigma_1\ \sigma_1$			**-0.4**			-28.4
☞ b. $L_1\ M_1\ \ H_{0.4} M_1$ $\sigma_1\ \sigma_1\ \ \sigma_1\ \sigma_1$				-1	**-0.6**	-28.2

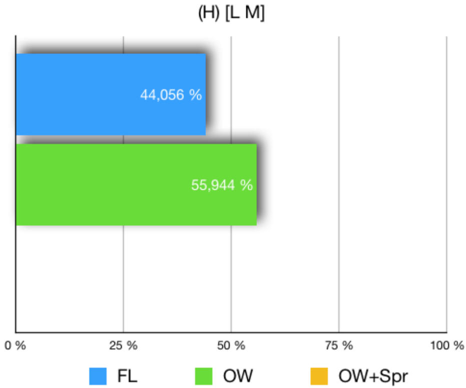
$0.4\times{}^{*}\textsc{Float} \sim \textsc{MaxT} + 0.6\times\textsc{Spec}$

MOL: H-Perturbation: Optional Realization of $H_{0.4}$: MaxEnt

(37)



$H_{0.4}$] [L_1 M_1] σ_1 σ_1	*H*	Probability
☞ a. $H_{0.4}$ L_1 M_1 σ_1 σ_1	-28,4	0,4406
☞ b. $H_{0.4}$ L_1 σ_1 σ_1	-28,16	0,5594
c. $H_{0.4}$ σ_1 σ_1	-34,5	3,29E-13



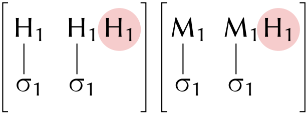
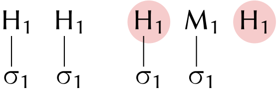
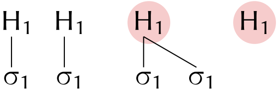
H-Spreading is Avoidance of a Marked Tone Sequence

- triggered by a markedness constraint against sequences of MH-tones inside a morpheme
  (and only spreading of floating H is a possible repair)

(38) *[MH]
Assign -X violation for every morpheme-internal sequence of M_1 and H_2 where X is the shared activity of M_1 and H_2.

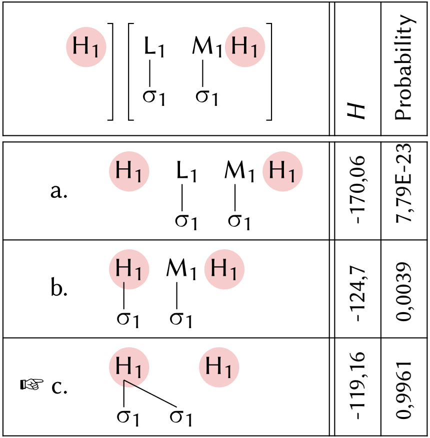
H-Spreading Triggered by H_1

(39)

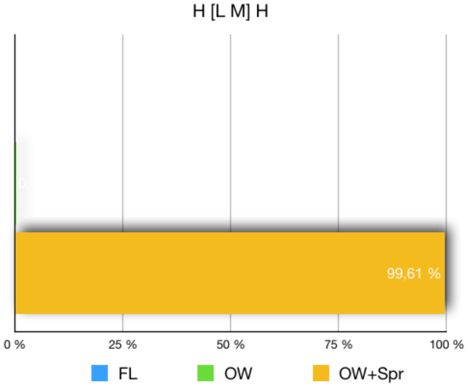
	MaxH	*Float	*[MH]	MaxT	
	100	71	28	24	
a. 		-1	-1	-1	-123
☞ b. 		-1		-2	-119

H-Spreading Triggered by H_1: Probabilities

(40)

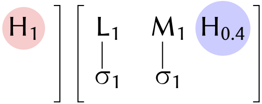
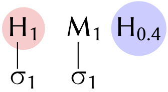
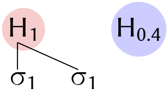


H_1][L_1 M_1 H_1]		H	Probability
a.	H_1 L_1 M_1 H_1	-170,06	7,79E-23
b.	H_1 M_1 H_1	-124,7	0,0039
☞ c.	H_1 H_1	-119,16	0,9961



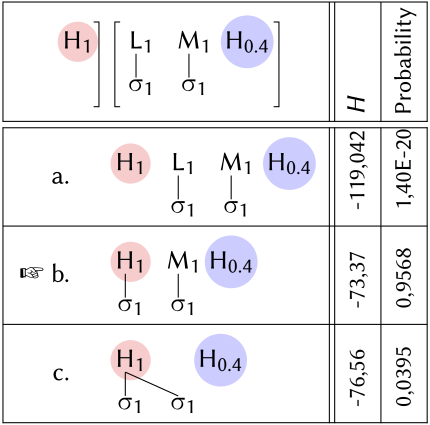
No H-Spreading Triggered by Partially Active $H_{0.4}$

(41)

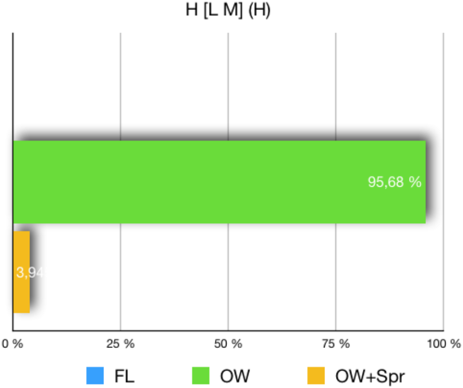
	MaxH 100	*Float 71	*[MH] 28	MaxT 24	
☞ a. 		-0.4	**-0.7**	-1	-72
b. 		-0.4		-2	-76,4

No H-Spreading Triggered by Partially Active $H_{0.4}$: Probabilities

(42)



H_1] [L_1 M_1 $H_{0.4}$] σ_1 σ_1		*H*	Probability
a.	H_1 L_1 M_1 $H_{0.4}$ σ_1 σ_1	-119,042	1,40E-20
☞ b.	H_1 M_1 $H_{0.4}$ σ_1 σ_1	-73,37	0,9568
c.	H_1 $H_{0.4}$ σ_1 σ_1	-76,56	0,0395



Prediction ②: Exceptionality for Multiple Processes

- the assumption of a partially active $H_{0.4}$ predicts the **two exceptional behaviours** from gradient constraint violations
- MaxEnt correctly predicts that the gradient activity results in both **variable and categorical** exceptionality

Exceptional optional trigger for H-perturbation

(43) Fully active H_1
$^*\textsc{Float} > \textsc{MaxT}$

(44) Partially active $H_{0.4}$
$0.4\times{}^*\textsc{Float} \sim \textsc{MaxT} + 0.6\times\textsc{Spec}$

Exceptional non-trigger for H-spreading

(45) Fully active H_1
$^*[\text{MH}] > \textsc{MaxT}$

(46) Partially active $H_{0.4}$
$\textsc{MaxT} > 0.7\times{}^*[\text{MH}]$

Prediction ④: Implicational Relations in MOL

- two additional exceptional morpheme(s) (classes) 2+4 are possible
- exceptional morpheme class 5 is impossible

(47)

			HP	HS	WA: HP	WA:HS
☞	1.	H_1	✔	✔	*FLOAT > MAXT	*[MH] > MAXT
	2.	$H_{0.6}$	✔	(✔)	0.6×*FLOAT > MAXT + 0.4×SPEC	0.6×*[MH] ∼ MAXT
☞	3.	$H_{0.4}$	(✔)	✖	0.4×*FLOAT ∼ MAXT + 0.6×SPEC	MAXT > 0.4×*[MH]
	4.	$H_{0.2}$	✖	✖	MAXT + 0.8×SPEC > 0.2×*FLOAT	MAXT > 0.2×*[MH]
*	5.	$H_?$	✖	✔	MAXT + (1-?)×SPEC > ?×*FLOAT	?×*[MH] >MAXT

HP=trigger for H-perturbation HS=trigger for H-spreading (if ending in M)

✔=yes (✔)=optional ✖=no

Case study 2: Exceptionality in Finnish

Exceptional Triggers and Undergoers: Finnish

(Anttila, 2002; Pater, 2006)

- exceptional repair for heteromorphemic /ai/ sequences
- type of repair (assimilation, deletion, or variation between both) is morpheme-specific

➙ **prediction ③ degrees of exceptionality**

Exceptional Triggers: Vowel Assimilation to Avoid /ai/ (Anttila, 2002)

- certain /i/-initial suffixes (Pl/Pst) trigger raising of a preceding /a/
- others (e.g. Cond) don't (48-b)

(48)

	underlying	surface		
a.	pala–i	paloi	'burn'–Pst	p.4
	tavara–i–ssa	tavaroissa	'thing'–Pl–Ine	p.5
	kana–i–ssa	kanoissa	'hen'–Pl–Ine	p.4
	kihara–i–ssa	kiharoissa	'curl'–Pl–Ine	p.13
	korea–i–ssa	koreoissa	'Korea'–Pl–Ine	p.13
	kahvi–la–i–ssa	kahviloissa	'cafe'–Pl–Ine	p.5
	kana–la–i–ssa	kanaloissa	'chicken shed'–Pl–Ine	p.5
b.	anta–isi	antaisi	'give'–Cond	(Pater, 2010, 133)

Exceptional Triggers: Vowel Deletion to Avoid /ai/ (Anttila, 2002)

- for certain morphemes, the exceptional triggers result in deletion of a preceding /a/

(49)

underlying	surface		
otta–i	otti	'take'–Pst	p.4
jumala–i–ssa	jumalissa	'God'–Pl–Ine	p.5
suola–i–ssa	suolissa	'salt'–Pl–Ine	p.6
kihara–i–ssa	kiharissa	'curly'–Pl–Ine	p.13
korea–i–ssa	koreissa	'beautiful'–Pl–Ine	p.13
tutki–va–i–ssa	tutkivissa	'researching'–Pl–Ine	p.5
anta–va–i–ssa	antavissa	'giving'–Pl–Ine	p.5

Exceptional Triggers: Alternation between Assimilation and Deletion

- for yet other morphemes, the exceptional triggers result in variation between deletion and assimilation

(50)

	underlying	surface	
itara–i–ssa	itaroissa ∼ itarissa	'stingy'–PL–INE	p.5
taitta–i	taittoi ∼ taitti	'break'–PST	p.6
omena–i-ssa	omenoissa ∼ omenissa	'apple'–PL–INE	p.9

Summary: Exceptional Triggers and Undergoers

- there are two ‘classes’ of (/i/-initial) suffixes:
  - NT no repair for /ai/-sequences
  - T repair for /ai/-sequences
- there are three ‘classes’ of (/a/-final) morphemes:
  - A assimilation before T-suffix
  - D deletion before T-suffix
  - AD assimilation/deletion before T-suffix

(51)

a#-morphemes	outcome	#i-morphemes
A AD D	ai	NT
A	oi	T
AD	oi $\sim$ i	
D	i	

Caution: Only Half the Story

- phonological regularities/tendencies:
  - deletion is more likely after a round vowel
  - deletion is more likely after a labial consonant
  - phonological generalizations apply exceptionless in underived bisyllabic stems

→ **Dissimilation** effects: deletion avoids two high/labial sounds

- N's typically assimilate, A's typically delete

GSRO Account in a Nutshell

T vs. NT suffixes

- default activity /i_1/ doesn’t induce enough violation of *ai to trigger repair
- higher activity /i_3/ results in threshold-crossing violation of *ai that triggers repair

D vs. A vs. AD

- default activity /a_1/ results in assimilation
- lower activity /$a_{0.6}$/ results in deletion: weak segment wants to be avoided
- intermediate activity /$a_{0.8}$/ shows variable behaviour

GSRO Account in a Nutshell

(52)

a#	surface	#i
A: /a_1/	[$a_1 i_1$]	NT: /i_1/
AD: /$a_{0.8}$/	[$a_{0.8} i_1$]	
D: /$a_{0.6}$/	[$a_{0.6} i_1$]	
A: /a_1/	[$o_1 i_3$]	T: /i_3/
AD: /$a_{0.8}$/	[$o_{0.8} i_3$] $\sim$ [i_3]	
D: /$a_{0.6}$/	[i_3]	

GSRO Account: Constraints

(53) a. *ai
Assign -X violations for every $[i]_X$ with activity X immediately preceded by an [a].

b. MAX[LW]
Assign -X violations for every activity X of [+low] that is present in the input but not the output.

c. MAX[HI]
Assign -X violations for every activity X of [+high] that is present in the input but not the output.

GSRO Account: Constraints

(54) a. *WEAK

Assign -1-X violations for every phonological element with activity X<1.

b. *STRONG

Assign -X-1 violations for every phonological element with activity X>1.

Avant: Segments Keep Their Underlying Activity in the Output

(55)

$t_1a_{0.6}$	DEPS 100	*WEAK 41	
☞ a. $t_1a_{0.6}$		-0.4	-16
b. t_1a_1	-0.4		-40

(56)

t_1a_3	MAXV 10	*STRONG 1	
☞ a. t_1a_3		-2	-2
b. t_1a_1	-2		-20

Non-Triggering Suffix and /a_1/

❧ a -1 violation of *ai is not important enough to trigger a repair

(57)

a_1 i_1	MAX[HI] 100	*WEAK 41	MAX[LW] 37	*ai 16	MAXV 10	
☞ a. a_1 i_1				-1		-16
b. o_1 i_1			-1			-37
c. i_1			-1		-1	-47
d. a_1 e_1	-1					-100
e. a_1	-1				-1	-110

Triggering Suffix and /a_1/

- the violation of *ai caused by a more active /i_3/ crosses the threshold for triggering a repair
- assimilation is optimal since V-deletion implies a superset of violations

(58)

a_1 i_3	*WEAK 41	MAX[LW] 37	*ai 16	MAXV 10	
a. a_1 i_3			**-3**		-48
☞ b. o_1 i_3		-1			-37
c. i_1		-1		-1	-47

Triggering Suffix and /$a_{0.6}$/

- for a weak V, deletion solves the additional problem of avoiding a weak segment

(59)

$a_{0.6}$ i_3	*WEAK 41	MAX[LW] 37	*ai 16	MAXV 10	
a. $a_{0.6}$ i_3	**-0.4**		-3		-64.4
b. $o_{0.6}$ i_3	**-0.4**	-1			-53.4
☞ c. $i_{0.6}$		-1		**-0.6**	-43

Non-Triggering Suffix and /$a_{0.6}$/

- no misprediction for weak segments outside of T-suffix-contexts: marked structure of a weak V is tolerated

(60)

$a_{0.6}$ i_1	*Weak	Max[lw]	*ai	MaxV	
	41	37	16	10	
☞ a. $a_{0.6}$ i_1	-0.4		-1		-32.4
b. $o_{0.6}$ i_1	-0.4	-1			-53.4
c. i_1		-1		-0.6	-43

Triggering Suffix and /$a_{0.8}$/

- V with a weak activity between those repairs: Optionality between both options*

(61)

$a_{0.8}$ i_3	*WEAK 41	MAX[LW] 37	*ai 16	MAXV 10		Probability
a. $a_{0.8}$ i_3	**-0.2**		-3		-56.2	2.5782981684922935E-6
☞ b. $o_{0.8}$ i_3	**-0.2**	-1			-45.2	0.5000118759256124
☞ c. i_3		-1		**-0.8**	-45	0.4999830712776138

0.2 x *WEAK $\sim$ 0.8 x MAXV

*Tableaux above: Winning candidate had a probability of at least 0.9999.

Recall: Phonological Regularities?

- account can easily integrate the account of the phonological conditions from Anttila (2002):
  - dissimilation effects follows from OCP constraints like $\text{OCP}_{\text{ROUND}}$
  - syllable-counting effect follows from domain-specific $\text{OCP}_{\text{ROUND}}\text{-}\varphi$
  - e.g. categorical restriction that deletion after /o/ in even-numbered stems: high-weight of $\text{OCP}_{\text{ROUND}}\text{-}\varphi$

(Lexical Factors of) Finnish Assimilation/Deletion in GSRO: Summary

Relevant activity thresholds

(62)

i_1 – not enough to trigger a repair to avoid a violation of *ai
i_3 – threshold to avoid *ai

(63)

a_1 – default repair of assimilation
$a_{0.8}$ – variation between assimilation and deletion
$a_{0.6}$ – deletion

(only activity differences for /a/ and /i/ were considered: activity differences for other vowels have no interesting effect (at least not for *ai)

Alternatives

Lexically Indexed Constraints

(e.g. Ito and Mester, 1990; Golston and Wiese, 1996; Fukazawa, 1999; Pater, 2000; Pater and Coetzee, 2005; Pater, 2006; Flack, 2007; Pater, 2010)

- constraints can exist in versions indexed to (classes of) morphemes that are only violated if the scope of the violation contains material of an indexed morpheme (Pater, 2010)

(64) Exceptional triggers and lexically indexed constraints

The exceptional triggers are indexed to a higher-ranked markedness constraint

Sh[bk]$_{\mathbf{A}}$, Sh[bk]$_{\textsc{hi}}$ $\gg$ Max[bk] $\gg$ Sh[bk]

(65) Exceptional non-undergoers and lexically indexed constraints

The exceptional non-undergoers are indexed to a higher-ranked faithfulness constraint

Max[bk]$_{\mathbf{B}}$ $\gg$ Sh[bk]$_{\textsc{hi}}$ $\gg$ Max[bk] $\gg$ Sh[bk]

Lexically Indexed Constraints and Our Four Predictions

① Unified account for (non)undergoers and (non)triggers ☹

- ➙ Exceptional non-triggers/undergoers are complement set of exceptional triggers/non-undergoers (=all ‘non-exceptional’ morphemes are indexed)

② Exceptionality for more than one process ☹

- ➙ Is a concidence: Morpheme (class) happens to be indexed to more than one constraint – two different explanations

③ Degrees of exceptionality ☺

- ➙ Fall out from more indexed versions of the same constraint(s)

④ Implicational restrictions between exceptionality patterns ☹

- ➙ Don’t exist
  e.g. $\textsc{MaxS}_{\text{B, C}}$, $\textsc{Sh}[\textsc{bk}]_{\text{A, B}}$, $\textsc{Sh}[\textsc{bk}]_{\textsc{hi}} \gg \textsc{Max}[\textsc{bk}]$, $^{*}\text{VV} \gg \textsc{Sh}[\textsc{bk}]$, $\textsc{MaxS}$

Autosegmental Defectivity

(Lieber, 1992; Stonham, 1994; Saba Kirchner, 2010; Trommer, 2011; Bermúdez-Otero, 2012; Bye and Svenonius, 2012; Trommer and Zimmermann, 2014; Zimmermann, 2017*c*)

- morphemes can be underspecified or overspecified: Floating features/moras/tones, lack of features/moras/tones,...

(66) Exceptional undergoers and autosegmental defectivity
Morphemes contain underspecified elements and need specification/escape faithfulness: e.g. vowel without [±back] feature undergoes non-parasitic harmony

(67) Exceptional triggers and autosegmental defectivity
Morphemes contain floating/unassociated features, moras, tones: e.g. morphemes with floating [±high] feature are triggers for non-parasitic vowel harmony

Autosegmental Defectivity and Our Four Predictions

① Unified account for (non)undergoers and (non)triggers ☺

② Exceptionality for more than one process ☺

- ➙ Exceptionality is a consequence from contrastive representations

③ Degrees of exceptionality ☹

- ➙ Severely limited by number of contrasting elements that can be lacking/floating

④ Implicational restrictions between exceptionality patterns ☹

- ➙ Don't exist; different representational properties (underspecification, floating elements) can freely be combined

Comparison: Three Accounts of Exceptionality

(68)

	LIC	ASD	GSRO
① 4 patterns	🟨 ☹	🟩 ☺	🟩 ☺
② More than one process	🟨 ☹	🟩 ☺	🟩 ☺
③ Degrees of exceptionality	🟩 ☺	🟥 ☹	🟩 ☺
④ Implicational restrictions	🟥 ☹	🟥 ☹	🟩 ☺

Summary

Summary

- the assumption of gradient activity in the output predicts the phonological exceptions from **gradient faithfulness and markedness violations**
- four properties of exceptionality patterns easily fall out that are hard to capture under alternatives
- outlook: activity differences can not only be a property of underlying representations, they can be derived in the phonology
  (Trommer, 2018*b*; Zimmermann, 2019; Walker, 2019)

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Appendix: GSRO and true gradience

- no inherent restriction on gradient contrasts within a language
  - 3 types of segments in Welsh:
    /$k_{1.0}$/ - /$r_{0.6}$/ - /$g_{0.2}$/
  - 3 types of association lines in Oku (Trommer and Zimmermann, 2018):
    /$\mathrm{H}-_{1.0}\bullet$/ - /$\mathrm{H}-_{0.6}\bullet$/ - /$\mathrm{H}-_{0.4}\bullet$/
  - 4 (derived) segment types in Levantine Arabic (Trommer, 2018*b*):
    /$i_{0.7}$/ - /$i_{0.6}$/ - /$i_{0.5}$/ - /$i_{0.3}$/
  - 5 types of feet in Moses Columbian Salish (Zimmermann, 2018*d*):
    /$\varphi_{1.0}$/ - /$\varphi_{0.9}$/ - /$\varphi_{0.8}$/ - /$\varphi_{0.6}$/ - /$\varphi_{0.4}$/

- vs. alternatives
  - most accounts based on autosegmental defectivity that only allow a binary distinction into [±defective] (e.g. Hyman, 1985; Noske, 1985; Kenstowicz and Rubach, 1987; Sloan, 1991; Yearley, 1995; Tranel, 1996; Zoll, 1996)
  - accounts that adopt ‘strength’ as a binary division
    (Inkelas, 2015; Vaxman, 2016*a*,*b*; Sande, 2017)

Open Question: The source for strength in GSR

- lexical contrast for phonological elements
- lexical contrast for whole morphemes (Faust and Smolensky, 2017)
- **derived in the phonology**:
    - ‘Gradient representations can mature or decay across layers’ (Trommer, 2018*b*)
    - stress strengthens elements (Faust and Smolensky, 2017; Amato, 2018; Trommer, 2018*b*)
    - floating strength strengthens elements (Amato, 2018)
    - fission is weakening/distribution of activity (Zimmermann, 2019)
    - certain features have an inherent strength and feature change thus implies strength adjustment (Walker, 2019)

MOL: No repair possible for *[MH] without a floating H

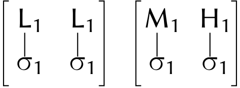
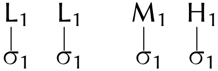
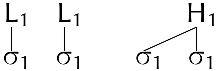
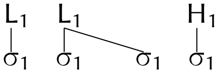
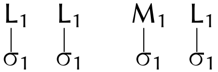
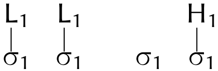
- simply deleting a tone is excluded by SPECIFY (=SPEC)
- deleting a tone and inserting one is excluded by DEPT
- spreading an underlying tone of the same morpheme is excluded by ALTERNATION
- spreading an underlyingly associated tone of a preceding morpheme is excluded by $*\text{LONG}_{\text{MBOUND}}$ (69)

(69) a. $*\text{LGT}_M$: Assign X violations for every tone T_1 that is associated to two TBU's τ_2 and τ_3 of different morphological affiliations where X is the shared activity of T_1, τ_2, and τ_3.

b. SPEC: Assign 1-X violations for every TBU τ_1 where X is the activity of tone(s) associated to τ_1.

MOL: No repair possible for *[MH] without a floating H

(70)

		ALT 100	*LGT$_M$ 100	DEPT 100	*[MH] 28	MAXT 24	SPEC 7	
								
☞ a.					-1			-28
b.		-1				-1		-124
c.			-1			-1		-124
d.				-1		-1		-124
e.						-1	-1	-31

Finnish: Actual Constraint weights calculated with the UCLA Maxent Grammar Tool Hayes (2009)

(71)
a. MAX[HI] =4.959766016953511
b. *WEAK =4.146982826416971
c. MAX[LW] =3.738127939601154
d. *ai =1.651884565610497 5
e. MAXV =1.0367529078026307
f. *STRONG =0.013893978300122 14