Gradient Symbolic Representations and the Typology of Phonological Exceptions

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Kolloquium

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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.

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- The assumption of Gradient Symbolic Representations that phonological elements can have different **degrees of activation** allows a unified explanation for patterns of exceptions.

- 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

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 underlying 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**
  - is **easier to tolerate** if it creates a marked structure

(1) Gradient activity=gradient constraint violations

$b_1a_1t_1$-$p_{0.5}$	*Weak 10	MaxS 10	DepS 10	*CC 10	
a. $b_1a_1t_1p_1$			**-0.5**	**-1**	-15
b. $b_1a_1t_1p_{0.5}$	**-0.5**			**-0.75**	-12.5
c. $b_1a_1p_{0.5}$	**-0.5**	**-1**			-15
☞ d. $b_1a_1t_1$		**-0.5**			-5

Only fully active S

Faithful realization of weak S

Deletion of fully active S

Deletion of weakly active S

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*c*)
   - exceptional tone (non)spreading in San Molinos Mixtec (Zimmermann, 2018*a*)
   - interaction of phonological/lexical gemination/lenition in Italian (Amato, 2018)
   - compound stress in Sino-Japanese (Rosen, 2018)
   - (interacting) ghost segments in Welsh (Zimmermann, 2018*b*)
   - …

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,...)

- **different from a binary** distinction into strong/weak
  (Inkelas, 2015; Vaxman, 2016*a*,*b*; Sande, 2017)

- 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),...)

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

GSRO and Exceptions

- if the underlying representation of two morphemes in a language contain identical phonological elements with different degrees of activity, they might show **different phonological behaviour** (=one is described as 'exception')

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- if the underlying representation of two morphemes in a language contain identical phonological elements with different degrees of activity, they might show **different phonological behaviour** (=one is described as 'exception')

  - → this **representational** explanation for different phonological behaviour **dispenses with true 'exceptionality'**: A single phonological grammar and contrasting underlying representations.

Case study: Exceptional vowels in Finnish

Exceptional Triggers and Undergoers: Finnish

(Anttila, 2002; Pater, 2006)

- exceptional repair for heteromorphemic /ai/ sequences

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

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

- certain /i/-initial suffixes (PL/PST) trigger raising of a preceding /a/
- other /i/-initial suffixes (e.g. COND) don't trigger raising (2-b)

(2)

	underlying	surface		
a.	pala–i	pal**oi**	'burn'–PST	p.4
	tavara–i–ssa	tavar**oi**ssa	'thing'–PL–INE	p.5
	kana–i–ssa	kan**oi**ssa	'hen'–PL–INE	p.4
	kihara–i–ssa	kihar**oi**ssa	'curl'–PL–INE	p.13
	korea–i–ssa	kore**oi**ssa	'Korea'–PL–INE	p.13
	kahvi–la–i–ssa	kahvil**oi**ssa	'cafe'–PL–INE	p.5
	kana–la–i–ssa	kanal**oi**ssa	'chicken shed'–PL–INE	p.5
b.	anta–isi	ant**ai**si	'give'–COND	(Pater, 2010, 133)

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

- for certain morphemes, the presence of an exceptional triggering suffix result in deletion of a preceding /a/

(3)

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, variation between deletion and assimilation is observed

(4)

	underlying	surface	
itara–i–ssa	itar**oi**ssa ∼ itar**i**ssa	'stingy'–Pl–Ine	p.5
taitta–i	taitt**oi** ∼ taitt**i**	'break'–Pst	p.6
omena–i-ssa	omen**oi**ssa ∼ omen**i**ssa	'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 ~*Exceptional Trigger*
- there are three 'classes' of (/a/-final) morphemes:
  - A assimilation before T-suffix
  - D deletion before T-suffix ~*Exceptional Undergoer 1*
  - AD assimilation/deletion before T-suffix ~*Exceptional Undergoer 2*

(5)

a#-morphemes	outcome	#i-morphemes
A AD D	ai	NT
A	oi	
AD	oi ∼ i	T
D	i	

Caution: Only Half the Story (Anttila, 2002)

- 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 of /i_1/ doesn't induce enough violation of *ai to trigger repair
- higher activity of /i_3/ results in a violation of *ai that crosses the threshold for a repair

D vs. A vs. AD

- default activity of /a_1/ results in assimilation
- lower activity of /$a_{0.6}$/ results in deletion since weak segments are marked and are preferably avoided
- intermediate activity of /$a_{0.8}$/ shows variable behaviour

GSRO Account in a Nutshell

- **lexical representations** of /a/-final and /i/-initial morphemes differ to predict A-AD-D and T-NT contrast

(6)

a#	surface	#i
A: /a_1/	[a_1i_1]	
AD: /$a_{0.8}$/	[$a_{0.8}i_1$]	NT: /i_1/
D: /$a_{0.6}$/	[$a_{0.6}i_1$]	
A: /a_1/	[o_1i_3]	
AD: /$a_{0.8}$/	[$o_{0.8}i_3$] ~ [i_3]	T: /i_3/
D: /$a_{0.6}$/	[i_3]	

GSRO Account: Constraints

(7) a. *ai *triggers raising/deletion*
Assign -X violations for every $[i]_X$ with activity X immediately preceded by an [a].

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

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

GSRO Account: Constraints

(8) 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

(9)

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

(10)

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

(11)

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

(12)

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 and the weak V is less protected by MaxV to begin with

(13)

$a_{0.6}$ 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_3		-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

(14)

$a_{0.6}$ i_1		*Weak 41	Max[lw] 37	*ai 16	MaxV 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

Additional Assumption: Variation and MaxEnt

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

Triggering Suffix and /$a_{0.8}$/

- V with an activity between 1-0.6 shows optionality between both repairs*

(15)

$a_{0.8}$ 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 ~ 0.8 x MaxV

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

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

Relevant activity thresholds: Underlying morpheme representations

(16)

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

(17)

- 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)

Recall: Phonological Regularities?

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

Four Predictions of the Model

GSRO: Four Predictions = Four Arguments

① A unified account for exceptional (non)undergoers and (non)triggers.
➙ *cf. Finnish case study*

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).
➙ *cf. Finnish case study*

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 (=VH)

pon–ek	→ ponok	*VH if same height*
put–ek	→ putek	*No VH if different height*

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1. Exceptional non-undergoer

Same height: No VH

pon– et → ponet, *ponot

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1. Exceptional non-undergoer

Same height: No VH

pon– et → ponet, *ponot

2. Exceptional non-trigger

Same height: No VH

ton –ek → tonek, *tonok

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2. Exceptional non-trigger

Same height: No VH

ton –ek → tonek, *tonok

3. Exceptional undergoer

Different height: VH

put– em → putom, *putem

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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

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

(18) a. SH[BK] *demands VH*
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 $\frac{A+B}{2}$.

b. $\text{SH[BK]}_{\text{HI}}$ *demands parasitic VH*
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 $\frac{A+B}{2}$.

c. ID[BK] *penalizes VH*
Assign -X violation for every input vowel V_X with another feature specification for [±back].

Toy Example: Four Patterns of Exceptionality in GSRO

(19) 'Regular': No VH if diff. height

/p₁u₁t₁–e₁k₁/	Id[BK] 15	Sh[BK]$_{HI}$ 10	Sh[BK] 10	
☞ a. [p₁u₁t₁e₁k₁]			-1	-10
b. [p₁u₁t₁o₁k₁]	-1			-15

Toy Example: Four Patterns of Exceptionality in GSRO

(19) 'Regular': No VH if diff. height

$p_1u_1t_1$–e_1k_1	Id[Bk] 15	Sh[Bk]$_{Hi}$ 10	Sh[Bk] 10	
☞ a. $p_1u_1t_1e_1k_1$			-1	-10
b. $p_1u_1t_1o_1k_1$	-1			-15

(20) 'Regular': VH if same height

$p_1o_1n_1$–e_1k_1	Id[Bk] 15	Sh[Bk]$_{Hi}$ 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

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

$k_1u_3n_1$ –e_1k_1	Id[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

Toy Example: Four Patterns of Exceptionality in GSRO

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Stronger stem-vowel enforces VH even if different height

$k_1u_3n_1$–e_1k_1	Id[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

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

$t_1o_{0.4}n_1$–e_1k_1	Id[BK] 15	Sh[BK]$_{HI}$ 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

(23) Exceptional undergoer:
Weaker affix-vowel undergoes VH even if different height

$p_1u_1t_1$– $e_{0.4}m_1$	ID[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

Toy Example: Four Patterns of Exceptionality in GSRO

(23) Exceptional undergoer:
Weaker affix-vowel undergoes VH even if different height

$p_1u_1t_1$– $e_{0.4}m_1$	Id[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

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

$p_1o_1n_1$– e_3t_1	Id[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

$E_{1\text{-}x}$ (=weaker than the 'default' element E_1)
can result in being an exceptional

- undergoer: Not as protected by faithfulness as E_1
- non-undergoer: Not inducing as much markedness violation as E_1
- non-trigger: Not inducing as much markedness violation as E_1

E_{1+x} (=stronger than the 'default' element E_1)
can result in being an exceptional

- undergoer: Inducing more markedness violation than E_1
- non-undergoer: Protected more by faithfulness as E_1
- trigger: 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

- ‘exceptional’ behaviour=activity of a phonological elements in a morpheme representation results in a gradient violation of constraint X

  → it also results in a gradient violation of constraint Y and might result in **‘exceptional’ behaviour for another process**

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*

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1. Exceptional trigger for VH

Different height: VH

ku –nek → kunok, *kunek

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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

(25) 'Regular': No VH if diff. height

p_1u_1–$n_1e_1k_1$	*VV 28	MaxS 20	Id[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

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

k_1u_3 –$n_1e_1k_1$	*VV 28	MaxS 20	Id[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 constraint

(27) *VV

Assign -X violation for every pair of adjacent vowels V_A and V_B where -X is the mean activity $\frac{A+B}{2}$

Exceptionality for More than one Process: GSRO

(28) 'Regular': VD to avoid hiatus

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

Exceptionality for More than one Process: GSRO

(28) 'Regular': VD to avoid hiatus

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

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

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

Exceptionality for More than one Process: GSRO

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

k_1u_3–$n_1e_1k_1$	*VV 28	MaxS 20	Id[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

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

k_1u_3–o_1k_1	*VV 28	MaxS 20	Id[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

Exceptionality for More than one Process: Empirical Picture

(32) e.g. exceptional H-realization in Molinos Mixtec
(Hunter and Pike, 1969; Zimmermann, 2018*a*)

	is realized	triggers spreading	undergoes spreading
H_1	Y	Y	Y
$H_{0.8}$	O	N	Y

(33) e.g. exceptional vowel harmony in Yucatec Mayan
(Krämer, 2001)

	undergoes full V-hamony	undergoes optional deletion
V_1	N	N
$V_{0.5}$	Y	Y

→ one threshold for two processes

③ Degrees of Exceptionality

- true gradience of activity=**multiple thresholds** for 'exceptional' behaviour within the same language for the same phonological element

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*

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*

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

(34) 'Regular': No VH if diff. height

$p_1o_1k_1$–i_1m_1	Id[Bk] 25	Sh[Bk]$_{Hi}$ 10	Sh[Bk] 10	
☞ a. $p_1o_1k_1i_1m_1$			-1	-10
b. $p_1o_1k_1u_1m_1$	-1			-25

(35) 'Regular': No VH if same height

$p_1o_1k_1$–e_1l_1	Id[Bk] 25	Sh[Bk]$_{Hi}$ 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

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

$t_1o_3m_1$ –i_1m_1	Id[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

(37) Exceptional trigger I: VH if same height

$t_1o_3m_1$ –e_1l_1	Id[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

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

$s_1o_5p_1$–i_1m_1	Id[Bk] 25	Sh[Bk]$_{Hi}$ 10	Sh[Bk] 10	
a. $s_1o_5p_1i_1m_1$			**-3**	-30
☞ b. $s_1o_5p_1u_1m_1$	-1			-25

(39) Exceptional trigger II: VH if same height

$s_1o_5p_1$–e_1l_1	Id[Bk] 25	Sh[Bk]$_{Hi}$ 10	Sh[Bk] 10	
a. $s_1o_5p_1e_1l_1$		**-3**	**-3**	-60
☞ b. $s_1o_5p_1o_1l_1$	-1			-25

Degrees of Exceptionality: Empirical picture

(40) e.g. exceptional /ai/-repair in Finnish *(cf. above)*

(Anttila, 2002; Pater, 2006)

	is deleted #_i_3	assimilates #_i_3
a_1	Y	N
$a_{0.8}$	O	O
$a_{0.6}$	N	Y

(41) e.g. exceptional H-tone realization in Giphende

(Hyman, 2017; Rolle, 2018)

	is realized with H in same word	is realized with adjacent H
H_1	Y	Y
$H_{0.8}$	Y	N
$H_{0.6}$	N	N

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

(42)

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: GSRO and Exceptionality Patterns

(43) Implicational restriction on exceptionality patterns
If a language L has more than two classes of morphemes with phonological elements that show different phonological behaviour with respect to different processes: The morpheme classes can be ordered in a way that all behaviours for a certain process form **continuous blocks**.

(44) Example: Excluded pattern with multiple self-reversing thresholds

	P1	P2
Morpheme 1	A1	B1
Morpheme 2	A1	B2
Morpheme 3	A2	B2
*Morpheme 4	A2	B1

Implicational Relations: Yet Another Toy Example

Lg4 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*

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Lg4 with parasitic VH and hiatus avoidance

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1. Exceptional trigger for VH

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

Implicational Relations: Yet Another Toy Example

Lg4 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 trigger for VH and non-undergoer of VD

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

Implicational Relations: Yet Another Toy Example

Lg4 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 trigger for VH and non-undergoer of VD

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

3. Exceptional non-undergoer of VD

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

Lg4 is Impossible in GSRO

(45) 'Normal': V with activity 1

a. Id[bk] > Sh[bk] *No non-parasitic VH*

b. *Hiat > MaxS *VD*

Lg4 is Impossible in GSRO

(45) 'Normal': V with activity 1

a. Id[bk] > Sh[bk] — *No non-parasitic VH*

b. *Hiat > MaxS — *VD*

(46) Exceptionality 1: V with activity X

a. X×Sh[bk] > Id[bk] — *Non-parasitic VH*

b. *Hiat > X×MaxS — *VD*

Lg4 is Impossible in GSRO

(45) 'Normal': V with activity 1

a. Id[bk] > Sh[bk] — *No non-parasitic VH*

b. *Hiat > MaxS — *VD*

(46) Exceptionality 1: V with activity X

a. X×Sh[bk] > Id[bk] — *Non-parasitic VH*

b. *Hiat > X×MaxS — *VD*

(47) Exceptionality 2: V with activity Y

a. Y×Sh[bk] > Id[bk] — *Non-parasitic VH*

b. Y×MaxS > *Hiat — *No VD*

Lg4 is Impossible in GSRO

(45) 'Normal': V with activity 1

a. Id[bk] > Sh[bk] — *No non-parasitic VH*

b. *Hiat > MaxS — *VD*

(46) Exceptionality 1: V with activity X

a. X×Sh[bk] > Id[bk] — *Non-parasitic VH*

b. *Hiat > X×MaxS — *VD*

(47) Exceptionality 2: V with activity Y

a. Y×Sh[bk] > Id[bk] — *Non-parasitic VH*

b. Y×MaxS > *Hiat — *No VD*

(48) *Exceptional 3: V with activity Z

a. Id[bk] > Z×Sh[bk] — *No non-parasitic VH*

b. Z×MaxS > *Hiat — *No VD*

Lg4 is Impossible in GSRO

(45) 'Normal': V with activity 1

a. Id[bk] > Sh[bk] — *No non-parasitic VH*

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(47) Exceptionality 2: V with activity Y

a. Y×Sh[bk] > Id[bk] — *Non-parasitic VH*

b. Y×MaxS > *Hiat — *No VD*

(48) *Exceptional 3: V with activity Z

a. Id[bk] > Z×Sh[bk] — *No non-parasitic VH*

b. Z×MaxS > *Hiat — *No VD*

→ **Weighting paradox** (Z < X and Z > X; (46) vs. (48))

Implicational Relations: The Empirical Picture

(49) Yine

(Lin, 1997*a*,*b*; Pater, 2010)

	triggers deletion	undergoes deletion
$V_{1.5}$	N	N
V_1	N	Y
$V_{0.5}$	Y	Y

(50) Welsh

(Zimmermann, 2019*b*)

	deletion to avoid coda	realized as default
C_1	N	Y
$C_{0.6}$	Y	Y
$C_{0.2}$	Y	N

(51) Finnish

(Anttila, 2002; Pater, 2006)

	is deleted #_i_3	assimilates #_i_3
a_1	Y	N
$a_{0.8}$	O	O
$a_{0.6}$	N	Y

(52) Lexical accent competition in Moses Columbian Salish

(Czaykowska-Higgins, 1985, 1993*a*,*b*, 2011; Willett, 2003; Zimmermann, 2018*c*)

	deleted if $\varphi_{>0.9}$ present	deleted if $\varphi_{>0.8}$ present	deleted if $\varphi_{>0.6}$ present	deleted if $\varphi_{>0.4}$ present
φ_1	N	N	N	N
$\varphi_{0.9}$	N	N	N	Y
$\varphi_{0.8}$	N	N	Y	Y
$\varphi_{0.6}$	N	Y	Y	Y
$\varphi_{0.4}$	Y	Y	Y	Y

→ multiple thresholds that are never **self-reversing**

Implicational Relations: The Important Details

- the implicational restriction crucially only holds for the **same phonological elements**

(53) An apparent counterexample:
Self-reversing thresholds in Yucatec Mayan vowels? (Krämer, 2001)

	undergoes full VH	optionally deletes	undergoes backness dissimimi-lation	undergoes height dissimimi-lation
V in most suffixes	N	N	N	N
V in some suffixes	Y	Y	N	N
V in some other suffixes	N	N	Y	N
V in one suffix	N	N	N	Y

Implicational Relations: The Important Details

- but the relevant constraints in Yucatec Mayan do not all refer to vowels, they in fact **refer to three different phonological elements**

(54) GSRO account of Yucatec Mayan

Threshold for *Weak

	delete	optionally copy V to fill mora
V_1	N	N
$V_{0.5}$	Y	Y

Threshold for OCP_{back}

	undergoes back-dissimilation
$[\pm back]_1$	N
$[\pm back]_{0.5}$	Y

Threshold for OCP_{high}

	undergoes height-dissimilation
$[\pm high]_1$	N
$[\pm high]_{0.5}$	Y

Alternative Accounts of Exceptionality

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)

Lexically Indexed Constraints

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- 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)

(55) Exceptional triggers and lexically indexed constraints

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

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

(56) Exceptional non-undergoers and lexically indexed constraints

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

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

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)

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

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③ Degrees of exceptionality ☺

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

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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. $\textsc{MaxS}_{B,\,C}$, $\textsc{Sh[bk]}_{A,\,B}$, $\textsc{Sh[bk]}_{HI} \gg \textsc{Id[bk]}$, $^{*}VV \gg \textsc{Sh[bk]}, \textsc{MaxS}$

Autosegmental Defectivity

(e.g. 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,...

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

(57) **Exceptional undergoers:** Morphemes contain underspecified elements and need specification/escape faithfulness

(58) **Exceptional triggers:** Morphemes contain floating/unassociated features, moras, tones that need association

(59) **Exceptional non-undergoers:** Morphemes contain underspecified elements and lack the element a constraint/process refers to or they contain additional material that makes them prone to more faithfulness

(60) **Exceptional non-triggers:** Morphemes contain underspecified elements and lack the element a constraint/process refers to

Autosegmental Defectivity and Our Four Predictions

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

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→ Exceptionality is a consequence from contrastive representations

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

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

(61)

	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 typology of phonological exceptions from **gradient faithfulness and markedness violations**
- four properties of exceptionality patterns easily fall out that are hard to capture under alternative accounts of exceptionality

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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):
    /H$-_{1.0}$•/ - /H$-_{0.6}$•/ - /H$-_{0.4}$•/
  - 4 (derived) segment types in Levantine Arabic (Trommer, 2018):
    /$i_{0.7}$/ - /$i_{0.6}$/ - /$i_{0.5}$/ - /$i_{0.3}$/
  - 5 types of feet in Moses Columbian Salish (Zimmermann, 2018*c*):
    /$\varphi_{1.0}$/ - /$\varphi_{0.9}$/ - /$\varphi_{0.8}$/ - /$\varphi_{0.6}$/ - /$\varphi_{0.4}$/
- 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)
  - stress strengthens elements (Faust and Smolensky, 2017; Amato, 2018; Trommer, 2018)
  - floating strength strengthens elements (Amato, 2018)
  - fission is weakening/distribution of activity (Zimmermann, 2019*a*)
  - certain features have an inherent strength and feature change thus implies strength adjustment (Walker, 2019)

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

(62)
a. MAX[HI] =4.959766016953511
b. *WEAK =4.146982826416971
c. MAX[LW] =3.738127939601154
d. *ai =1.6518845656104975
e. MAXV =1.036752907802630 7
f. *STRONG =0.01389397830012214