Gradience in Phonology:
The Argument from Exceptions

PΦF, Princeton

April 06, 2019

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Main Claim

- The assumption of Gradient Symbolic Representations (Smolensky and Goldrick, 2016; Rosen, 2016) that phonological elements can have different degrees of activation allows a unified explanation for the typology of **phonological exceptions**.
- Predictions about exceptionality patterns:
  - exceptional elements can be **exceptional for multiple processes**
  - different **degrees of exceptionality**
  - **implicational relations** between exceptionality classes within a language

Exceptions: Toy Example

A general phonological rule in Lg1: Nasalization

pok–el → pokel
pon–el → ponẽl (V → Ṽ /[+nasal]__)

1. Exceptional non-undergoer

(for nasalization)

pon– et → ponet, *ponẽt

2. Exceptional non-trigger

(for nasalization)

ton –el → tonel, *tonẽl

3. Exceptional undergoer

(for backness harmony)

pok– ek → pokok, *pokek

4. Exceptional trigger

(for nasalization)

tok –el → tokẽl, *tokel

Pattern 1: A Morpheme is Exceptional for More than one Process

A general phonological rule in Lg2: Nasalization

pok−el → pokel
pon−el → ponẽl (V → Ṽ /[+nasal]__)

1. Exceptional non-undergoer

(for nasalization)

pon− et → ponet, *ponẽt

2. Exceptional non-trigger

(for nasalization)

ton −el → tonel, *tonẽl

3. Exceptional undergoer

(for backness harmony)

pok− et → pokot, *poket

4. Exceptional trigger

(for nasalization)

tok −el → tokẽl, *tokel

Pattern 2: Different Degrees of Exceptionality

Lg3 without backness harmony

pok–el → pokel

Exceptional undergoer I

(for backness harmony)

pok–et → pokot, *poket
put–et → putot, *putet

Exceptional undergoer II

(for backness harmony, parasitic on height)

pok–em → pokom, *pokem
put–em → putem, *putom

Plan

1. Gradient Symbolic Representations: Assumptions
2. Exceptionality for More than one Process
3. Different Degrees of Exceptionality
4. Implicational Relations between Exceptionality Classes
5. Discussion

Gradient Symbolic Representations: Assumptions

Gradient Symbolic Representation (=GSR)

- All linguistic symbols have **activity** that can **gradiently** differ with 1=fully active. (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 weakly active in the output and thus violate **markedness 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)

GSR: Gradient Constraint Violations

(Cf. Walker (2019) for potential problems and scaling factors as an alternative)

- Weakly active segments:
  - they are **easier to delete** than ‘normal’ segments (=MaxS violated to a lesser degree)
  - it is **costly to realize** them (=activity inserted (1-a) or weak activity in the output (1-b+c))
  - they **violate/satisfy** markedness constraints to a lesser degree

(1) Gradient Activity=gradient constraint violations

$b_1a_1t_1$-$p_{0.5}$		Full!	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

(2) Full!: Assign violation 1-X for every output element with activity X.

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)

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

tātá-są́	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))

(4) H-overwriting

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

Process 1: H-Perturbation

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

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

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

(6) H-overwriting and spreading

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

Process 2: H-Spreading after Perturbation

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

	M1	M2	Surface	Tones
H-overwriting and spreading				
a.	**síví**^{H}	**sùtʃī**^{H}	síví s**ú**tʃ**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: **XX$^{\mathbf{H}}$**
     - trigger H-perturbation
     - trigger H-spreading if they end in an M
  3. **optionally perturbing** ones: **XX$^{\mathbf{(H)}}$**
     - 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

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

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

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

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

	M1	M2	Surface	Tones
Never a trigger…				
a.	**sívíᴴ** ‘name’	**ʧḭ̀ʔḭ̄⁽ᴴ⁾** ‘skunk’	síví ʧ**ḭ́**ʔḭ̄ ‘name of the skunk’	$HH^{H}+LM^{(H)}\rightarrow HH$ **H**M
b.	**hìkī⁽ᴴ⁾** ‘fist, paw’	**ʧḭ̀ʔḭ̄⁽ᴴ⁾** ‘skunk’	hìkī ʧ**ḭ́**ʔḭ̄∼ʧḭ̀ʔḭ̄ ‘the skunk’s paw’	$LM^{(H)}+LM^{(H)}\rightarrow LM$ **H**M∼LM
…but always an undergoer (if realized)				
c.	**ʧḭ̀ʔḭ̄⁽ᴴ⁾** ‘skunk’	**kāāᴴ** ‘to eat’	ʧḭ̀ʔḭ̄ k**áá**∼kāā ‘the skunk will eat (it)’	$LM^{(H)}+MM^{H}\rightarrow LM$ **HH**∼MM
d.	**hìkī⁽ᴴ⁾** ‘fist’	**sùʧīᴴ** ‘child’	hìkī s**ú**ʧ**í**∼sùʧī ‘the child’s fist’	$LM^{(H)}+LM^{H}\rightarrow LM$ **HH**∼LM

GSR 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 (=optionality modeled with MaxEnt (Johnson, 2002; Goldwater and Johnson, 2003; Wilson, 2006) where well-formedness is interpreted as probability; calculated with (Hayes, 2009))
    - the weakly active $H_{0.4}$ is not a bad enough problem for the markedness constraint *[MH] triggering H-spreading

Constraints

(10) 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.

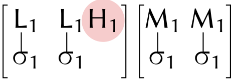
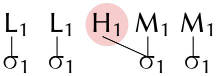
b. MAXT: Assign violation X for any tonal activity X in the input that is not present in the output.

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$_1$

(11)

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

*Float ≫ MaxT

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

(12)

$\left[\begin{matrix}L_1 & MH_{0.4}\\ \vert & \vert \\ \sigma_1 & \sigma_1\end{matrix}\right]\left[\begin{matrix}L_1 & M_1\\ \vert & \vert \\ \sigma_1 & \sigma_1\end{matrix}\right]$	Max$_{\text{H}}$ 100	*Cont 100	*Float 71	MaxT 24	Spec 7	
☞ a. $\begin{matrix}L_1 & M & H_{0.4} & L_1 & M_1\\ \vert & \vert & & \vert & \vert \\ \sigma_1 & \sigma_1 & & \sigma_1 & \sigma_1\end{matrix}$			-0.4			-28.4
☞ b. $\begin{matrix}L_1 & M_1 & H_{0.4} & M_1\\ \vert & \vert & \vert & \vert \\ \sigma_1 & \sigma_1 & \sigma_1 & \sigma_1\end{matrix}$				-1	-0.6	-28.2

0.4×*Float ∼ MaxT + 0.6×Spec

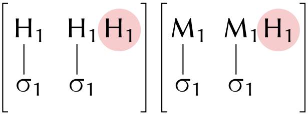
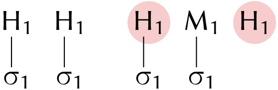
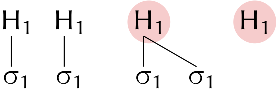
H-Spreading is Avoidance of a Marked Tone Sequence

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

(13) *[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

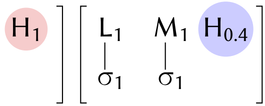
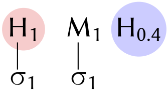
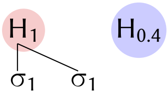
(14)

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

*[MH] ≫ MaxT

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

(15)

	MAX$_\text{H}$ 100	*FLOAT 71	*[MH] 28	MAXT 24	
☞ a. 		-0.4	-0.7	-1	-72
b. 		-0.4		-2	-76,4

$\text{MAXT} \gg 0.7 \times {}^*[\text{MH}]$

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

- the assumption of a partially active $H_{0.4}$ predicts the **two exceptional behaviours** from gradient constraint violations

Exceptional optional trigger for H-perturbation

(16) Fully active H_1
*FLOAT ≫ MAXT

(17) Partially active $H_{0.4}$
$0.4\times$*FLOAT ∼ MAXT + $0.6\times$SPEC

Exceptional non-trigger for H-spreading

(18) Fully active H_1
*[MH] ≫ MAXT

(19) Partially active $H_{0.4}$
MAXT ≫ $0.7\times$*[MH]

Different Degrees of Exceptionality

Welsh Ghost Segments 1

(20) Ghost consonant in Welsh (Hannahs and Tallerman, 2006, 798)

a. guda**g** eraill ‘with others’
b. guda gwên ‘with a smile’

Ghost segments: /gudag👻/

Several morphemes surface with an unpredictable consonant only if its appearance avoids a vowel hiatus.

- Those are **appearing ghosts** that only appear to solve a problem.
- Their default state is to **not be there**.

Welsh Ghost segments 2

(21) Welsh definite allomorphy (Hannahs and Tallerman, 2006, 782+783)

a.	**yr** afon	‘the river’	yr (=ər) __ V
b.	**y** llyfr	‘the book’	y (=ə) __ C
c.	o**’r** afon o**’r** llyfr	‘from the river’ ‘from the book’	/’r/ (=r) V__, overriding a.+b.

Ghost segments: /y👻r👻/

A single underlying form /y👻r👻/ and either one of these segments can remain unrealized if it would result in a marked structure (=coda or hiatus).

- Those are **disappearing ghosts** that disappear to avoid a problem.
- Their default state is to **be there**.

Welsh: Ghost segments 1+2 combined

(22) Ghost segments 1+2 combined (Hannahs and Tallerman, 2006, 784)

Underlying	Surface	
gyda**g**👻 **y**👻**r**👻 nod	gyda**'r** nod	'with the aim'

- Why not /gyda**g**👻 **y**👻 nod/ without an additional coda?
  - ➙ because /**g**👻/ is only realized to avoid hiatus, not codas
- Why not /gyda**g**👻 **y**👻**r**👻 nod/ with same additional coda?
  - ➙ because /**g**👻/ is not realized in the default case when markedness is not decisive

Ghosts in Welsh: Summary

(23) *Segments with different behaviour in Welsh*

	default state	non-default state due to	
		*Coda	*Hiat
g👻	not present	no	yes
y👻	present	–	yes
r👻	present	yes	–
n_1	present	no	no

- different thresholds: Is realization more costly or deletion?
- different thresholds: Is *Coda important enough to trigger non-default-state

Welsh Ghost Segments: GSR Account

$$/g_1u_1d_1a_1\mathbf{g}_{\mathbf{0.2}}/ \text{ and } /\mathbf{y}_{\mathbf{0.6}}\mathbf{r}_{\mathbf{0.6}}/$$

- /$\mathbf{y}_{\mathbf{0.6}}$/ and /$\mathbf{r}_{\mathbf{0.6}}$/ are realized unless their realization would create a *Coda or *Hiat violation
- /$\mathbf{g}_{\mathbf{0.2}}$/ is not realized unless it can avoid a *Hiat violation

If only fully active output segments are possible (high-weighted Full!):

(24) */$S_{0.2}$/ is more absent than present*

$g_1u_1d_1a_1\mathbf{g}_{\mathbf{0.2}}$	MaxS 10	DepS 10	
a. $g_1u_1d_1a_1\mathbf{g_1}$		-0.8	-8
☞ b. $g_1u_1d_1a_1$	-0.2		-2

$0.8\times\text{DepS} \gg 0.2\times\text{MaxS}$

(25) */$S_{0.6}$/ is more present than absent*

$\mathbf{y}_{\mathbf{0.6}}\mathbf{r}_{\mathbf{0.6}}$	MaxS 10	DepS 10	
☞ a. $\mathbf{y_1r_1}$		-0.8	-8
b.	-1.2		-12

$0.6\times\text{MaxS} \gg 0.4\times\text{DepS}$

Appearing /$g_{0.2}$/: Realized to Avoid a Vowel Hiatus

(26)

$g_1u_1d_1a_1\mathbf{g_{0.2}}$ $V_1\ldots$	MAXS 10	DEPS 10	*[CC 8	*HIAT 7	*CODA 5	
☞ a. $g_1u_1.d_1a_1.\mathbf{g_{0.2}}V_1$		-0.8				-8
b. $g_1u_1.d_1a_1.V_1$	-0.2			-1		-9

*HIAT + 0.2×MAXS ≫ 0.8×DEPS

Disappearing /$y_{0.6}r_{0.6}$/: /r/ Disappears to Avoid a Coda

(27)

…V_1C_1 **$y_{0.6}r_{0.6}$** C_1V_1…	MAXS 10	DEPS 10	*[CC 8	*HIAT 7	*CODA 5	
a. $V_1.C_1$**y_1r_1**$.C_1V_1$		-0.8			-1	-13
☞ b. $V_1.C_1$**y_1**$.C_1V_1$	-0.6	-0.4				-10
c. $V_1C_1.$**r_1**C_1V_1	-0.6	-0.4	-1		-1	-23
d. $V_1.C_1V_1$	-1.2					-12

*CODA + 0.4×DEPS ≫ 0.6×MAXS

Disappearing /$y_{0.6}r_{0.6}$/: /r/ Disappears to Avoid a Hiatus

(28)

…V_1 **$y_{0.6}r_{0.6}$** V_1…	MAXS 10	DEPS 10	*[CC 8	*HIAT 7	*CODA 5	
a. V_1.**y_1.r_1**V_1		-0.8		-1		-15
b. V_1.**y_1**.V_1	-0.6	-0.4		-2		-24
☞ c. V_1.**r_1**V_1	-0.6	-0.4				-10
d. V_1.V_1	-1.2			-1		-19

*HIAT + 0.4×DEPS $\gg$ 0.6×MAXS

Combination of Appearing and Disappearing Ghosts

(29)

$g_1u_1d_1a_1g_{0.2}\ y_{0.6}r_{0.6}\ C_1V_1\ldots$	RM 100	MaxS 10	DepS 10	*[CC 8	*Hiat 7	*Coda 5	
a. $g_1u._1d_1a_1.g_1y_1r_1.C_1V_1$			-1.6			-1	-21
b. $g_1u._1d_1a_1.y_1r_1.C_1V_1$		-0.2	-0.8		-1	-1	-22
☞ c. $g_1u._1d_1a_1r_1.C_1V_1$		-0.8	-0.4			-1	-17
d. $g_1u._1d_1a_1.g_1y_1.C_1V_1$		-0.6	-1.2				-18

- ➙ vs. (29-d): /$g_{0.2}$/ **never shows its non-default state to avoid codas**
  0.8×DepS ≫ *Coda
- ➙ vs. (29-a): /$g_{0.2}$/ is an appearing ghost and its **default state is thus to not be there**
  0.8×DepS ≫ 0.2×MaxS

Ghosts in Welsh: Summary

(30) *Segments with different behaviour in Welsh*

	default state	non-default state due to	
		*Coda	*Hiat
$g_{0.2}$	not present (24)	no (29)	yes (26)
$y_{0.6}$	present (25)	–	yes (29)
$r_{0.6}$	present (25)	yes (27)	–
n_1	present (34)	no (34)	no (34)

- different thresholds: Is realization more costly or deletion?
- different thresholds: Is *Coda important enough to trigger non-default-state

Implicational Relations between Exceptionality Classes

GSR Prediction: Implicational Relations

(31) Impossible exceptionality pattern (from strength differences alone)

	Triggers/undergoes Process P_1	Triggers/undergoes Process P_2
Normal element	✔	✔
Exceptional element 1	✔	✖
Exceptional element 2	✖	✖
* Exceptional element 3	✖	✔

Implicational Relations: Example MOL^{I}

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

(32)

		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

Discussion

Further Prediction: 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):
    $/H\!-_{1.0}\!\bullet/$ - $/H\!-_{0.6}\!\bullet/$ - $/H\!-_{0.4}\!\bullet/$
  - 4 (derived) segment types in Levantine Arabic (Trommer, 2018*a*):
    $/i_{0.7}/$ - $/i_{0.6}/$ - $/i_{0.5}/$ - $/i_{0.3}/$
  - 5 types of feet in Moses Columbian Salish (Zimmermann, to appear):
    $/\varphi_{1.0}/$ - $/\varphi_{0.9}/$ - $/\varphi_{0.8}/$ - $/\varphi_{0.6}/$ - $/\varphi_{0.4}/$

- 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)

Further Prediction: Surface activity and phonetic interpretation

- phonetic gradience in phonology:
  - subphonemic gradience in word-final devoicing, nasal place assimilation, flapping (Braver, 2013, e.g.)
  - vowel harmony is gradient; gets weaker the farther it spreads (McCollum, 2018)

→ a convincing example would be one where phonetic gradience and exceptional phonological behaviour stemming from underlying weakness coincide

Open Question: The source for strength

- 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*a*)
  - stress strengthens elements (Faust and Smolensky, 2017; Amato, 2018; Trommer, 2018*a*)
  - 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)

Arguments for GSR

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, to appear)
   - 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)
   - stress-syncope interaction in Levantine Arabic (Trommer, 2018*b*)
   - (interacting) ghost segments in Welsh (Zimmermann, 2018*c*)
   - …

Summary

- the assumption of GSR with activity in the output predicts the typology of exceptions from **gradient faithfulness and markedness violations**
- certain elements are predicted to be **exceptional for more than one process**
  - argument against lexically indexed constraints (e.g. Alderete, 2001; Pater, 2010; Finley, 2009))
  - argument against autosegmental defectivity accounts since gradient violations of constraints directly referring to this element are sufficient
- different **grades of exceptionality** are predicted
- **implicational restrictions** between exceptions are predicted

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Welsh: Ghost segments 1+2 combined

(33) Underlying: /gyda**g**👻 **y**👻**r**👻 nod/ (Hannahs and Tallerman, 2006, 784)

		ghost deleted	ghost realized	marked
* Option 1:	gyda**g** **y** nod	☹	☹ ☹	☺
☞ Option 2:	gyda**'r** nod	☹ ☹	☹	☹

'with the aim'

Realization of /r/ takes precedence over the other ghost segments

- one of the reasons Hannahs and Tallerman (2006) reject a phonological account of the definite allomorphy
- → follows in an account based on gradient activity where segment can have different default states: /g/'s **default state is not to be there**

Welsh: Markedness and Non-Ghosts in Welsh

- non-ghost segments are neither deleted nor inserted to avoid *Hiat and/or *Coda problems

(34)

$\ldots V_1\ a_1f_1o_1n_1\ C_1V_1\ldots$	MaxS	DepS	*[CC	*Hiat	*Coda	
	10	10	8	7	5	
☞ a. $V_1.a_1.f_1o_1n_1.C_1V_1$				-1	-1	-12
b. $V_1.a_1.f_1o_1.C_1V_1$	-1			-1		-17
c. $V_1.\text{ʔ}_1a_1.f_1o_1n_1.C_1V_1$		-1			-1	-15
d. $V_1.\text{ʔ}_1a_1.f_1o_1.C_1V_1$	-1	-1				-20

MaxS $\gg$ *Coda/*Hiat
DepS $\gg$ *Coda/*Hiat

MOL: Perturbing Morphemes: Summary

- the optionally perturbing morphemes
  - only optionally trigger H-Perturbation
  - never trigger H-Spreading

M2 M1	XX	**XM$^{(H)}$**	**XM^{H}**	
XX	no change	no change	no change	
XX$^{(H)}$	no change or H-OW	no change or H-OW	no change or H-OW+Spr	⇒ **Sometimes H-OW trigger**
XX^{H}	H-OW	H-OW	H-OW+Spr	⇒ **Always H-OW trigger**
		⇓ **Never H-Spr trigger**	⇓ **Always H-Spr trigger**	

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

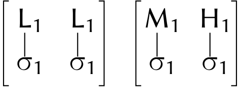
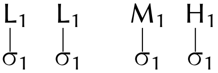
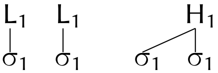
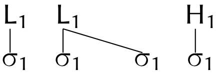
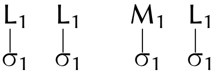
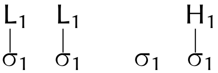
- simply deleting a tone is excluded by SPECIFY (=SPEC)
- deleting a tone and inserting one is excluded by DEPT
- spreading an underlying tone of the same morpheme is excluded by ALTERNATION
- spreading an underlyingly associated tone of a preceding morpheme is excluded by $^{*}\text{LONG}_{\text{MBOUND}}$ (35)

(35) 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.

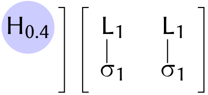
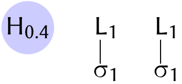
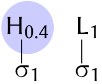
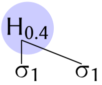
MOL: No repair possible for *[MH] without a floating H

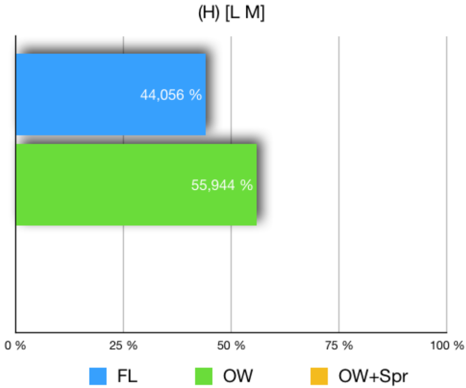
(36)

		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

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

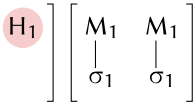
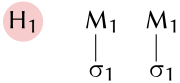
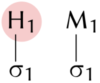
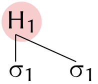
(37)

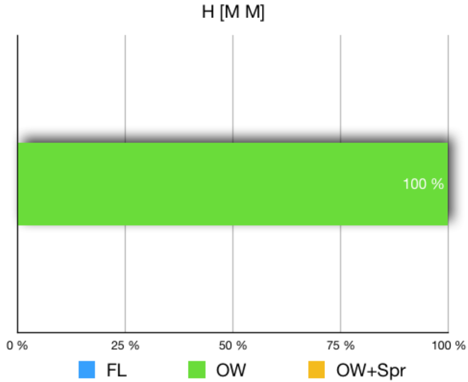
	*H*	Probability
☞ a. 	-28,4	0,4406
☞ b. 	-28,16	0,5594
c. 	-34,5	3,29E-13



MOL: Fully active H_1 is realized: Maxent probabilities

(38)

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



GSR Prediction: Implicational Relations, Toy Example

- Given a Lg where unexceptional S never undergoes process P_1 or P_2 to avoid the markedness violations M_1 or M_2 respectively:
- (and only gradient faithfulness is relevant, not gradient markedness)

(39)

	P_1	P_2		
S_1	✖	✖	Faith $\gg M_1$	Faith $\gg M_2$
$S_{0.6}$	✔	✖	$M_1 \gg 0.6\times$Faith	$0.6\times$Faith $\gg M_2$
$S_{0.4}$	✔	✔	$M_1 \gg 0.4\times$Faith	$M_2 \gg 0.4\times$Faith
* $S_{???}$	✖	✔	??? x Faith $\gg M_1$	$M_2 \gg$??? x Faith