



# Modeling vowel quantity scales in Q Theory

Karee Garvin, Myriam Lapierre, Martha Schwarz, and Sharon Inkelas

Annual Meeting on Phonology 2019  
Stonybrook

# Roadmap

- Introduction
- A Four-Point Strength Scale
- Motivating a Formal Scale
  - Subsegments and Weight
  - Comparing Representational Models
- Formalizing the Scale

# Introduction

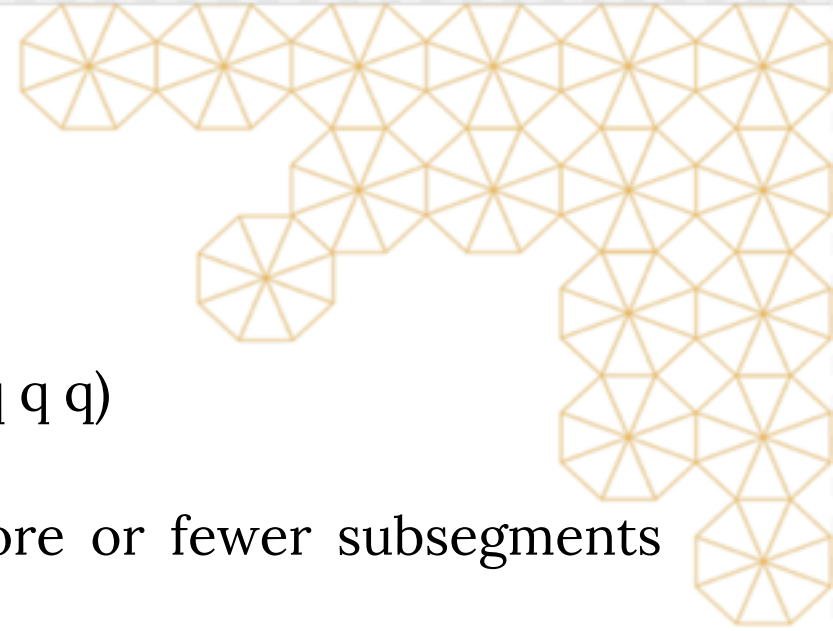
- Vowels exhibit a **wide range of behaviors** with respect to a number of phonological phenomena
  - quantity-sensitivity in stress assignment
  - faithfulness
  - harmony
  - etc.
- Previous literature has captured differences in vowel quantity in two binary ways
  - Representational difference between **short** ( $\mu$ ) or **long** ( $\mu\mu$ ) vowels; and
  - Derivational distinction between **underlying** or **inserted** vowels

# Introduction

- The cross-linguistic range of **vowel strength** requires a **scalar approach**
  - with greater than binary distinction
- Using **Q Theory** (e.g. Shih & Inkelas, 2019), we model surface vowel strength quantitatively
  - manipulating the **number of subsegments** in a vowel (see also Schwarz et al. 2019)
- These representations interact with faithfulness and markedness constraints
  - correctly predicts quantity-sensitivity effects



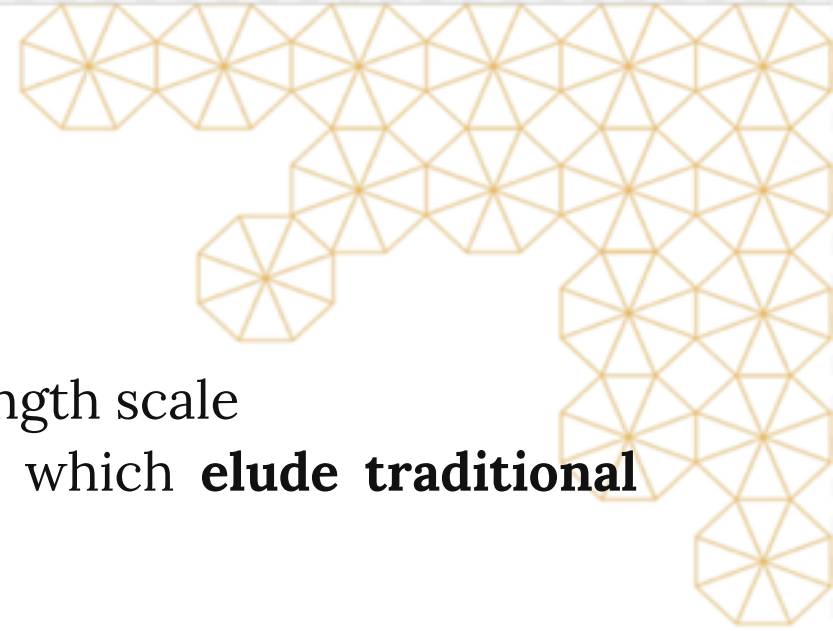
# **A Four-Point Strength Scale**



# A four-point scale

- In Q Theory, a canonical segment has **three subsegments** (q q q)
  - Roughly corresponds to onset, target, and offset.
- Segments may deviate from this canon by possessing more or fewer subsegments (Inkelas & Shih 2017, Garvin et al. 2018)
- This four-point scale ranges from superlight (**v**) to phonologically long (**v v v v**)
  - **This** captures the observed range of behaviour in ways previous representations cannot

**Weakest vowels** | (**v**)    (**v v**)    (**v v v**)    (**v v v v**) | **Strongest vowels**



# A four-point scale

- Not all languages require all four points on the vowel strength scale
  - But many exhibit differences between short vowels which **elude traditional phonological representations**
- Turkish (Bellik 2018) and Moroccan Arabic (Gafos 2002) distinguish between
  - **canonical**, lexical vowels, range over the full vowel inventory
  - **epenthetic** vowels, exhibit a restricted inventory of targets
  - **'excrescent'** vowels, lack a distinct target and shorter in duration

# Case study: Panãra (Jê) vowels

<p><b>Superlight: v</b></p>	<p>/krɾ/ → [k<sup>ɾ</sup>rɾ] <i>thigh</i>          (kkk) ɾ (rr) (ɾɾɾ)</p>	<ul style="list-style-type: none"> <li>• Arise in stop-approximant clusters</li> <li>• Quality entirely determined by adjacent segments (consonants and vowels)</li> </ul>
<p><b>Light: (v v)</b></p>	<p>/tɛp/ → [tɛ.p<sup>i</sup>] <i>fish</i>          (t t t) (ɛ ɛ ɛ) (p p p) <b>(i i)</b></p>	<ul style="list-style-type: none"> <li>• Resolve ban on word-final consonants</li> <li>• Despite otherwise systematic final stress, epenthetic Vs cannot bear stress</li> <li>• Default quality is [i]</li> </ul>
<p><b>Canonical: (v v v)</b></p>	<p>/po/ → [p<sup>o</sup>] <i>white</i>          (p p p) <b>(o o o)</b></p>	<ul style="list-style-type: none"> <li>• Can be stressed</li> <li>• All vowel qualities available</li> </ul>
<p><b>Long: (v v v v)</b></p>	<p>/po:/ → [po:] <i>to arrive</i>          (p p p) <b>(o o o o)</b></p>	<ul style="list-style-type: none"> <li>• Contrast with short vowels for 13 vowel qualities</li> </ul>



# **Skeletal units vs. weight units**

# Subsegments are skeletal units

- Q Theory can represent the difference between full (v v v) and long (v v v v) vowels in terms of subsegmental quantity

(v<sup>1</sup> v<sup>2</sup> v<sup>3</sup>)

(v<sup>1</sup> v<sup>2</sup> v<sup>2</sup> v<sup>3</sup>)

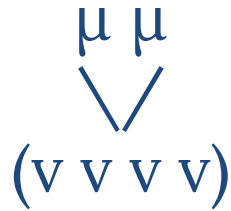
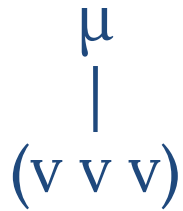
- How does this compare with the use of moras to distinguish a long V from a short one?

μ  
|  
V

μ μ  
∨  
V

# Subsegments and weight

- The approaches are compatible:



- Subsegments are an augmentation of skeletal units, not a replacement for moras

# Subsegments and weight

- We adopt the standard view that moras are emergent from the grammar, under language-specific conditions referring to vowel strength and to syllable structure (e.g., Zec 2003, Morén 2000, Ryan 2018).
- Instead of (only) projecting moras from V and C units based on syllable position (e.g., Hayes 1989), Q Theory (also) projects moras based on subsegmental quantity, e.g.:
  - If (v v), (v v v) or (v v v v), then project a mora
  - If (v v v v v) then project two moras

# Subsegments and weight

- Subsegments help encode length and weight distinctions that moras, on their own, have been shown to be insufficient to capture
  - Ryan (2018): the ternary  $VVC > VV > VC > V$  weight scale is **not always reducible to  $\mu$  vs.  $\mu\mu$**
  - **'Coercion'** (e.g., Morén 2000) helps in some but not all cases
  - Ryan (2018): the mora scale has to be supplemented with **other prominence scales** (e.g., VV-stress).
- We agree: augmenting skeletal (  $V$  ) units with subsegmental (  $v$  ) units accomplishes this



# Comparing Representational Models

# Comparing Representational Models

- While distinctions between underlying status and moraic structure are able to capture many of the observed differences in vowel strength, neither representation is fine-grained enough to capture the full scale strength scale.

	Underlying	Inserted
$\mu$	V	V
$\mu\mu$	VV	VV

# Comparing Representational Models

- While distinctions between underlying status and moraic structure are able to capture many of the observed differences in vowel strength, neither representation is fine-grained enough to capture the full scale strength scale.
- Subsegments offer the necessary representational tool to generate a strength scale that captures the full range of attested strength behavior.

	Underlying	Inserted
$\mu$	V	V
$\mu\mu$	VV	VV

Super Light	Light	Canonical	Strong
v	vv	vvv	vvvv

# Representational Models: Short vowels

- Both underlying and inserted vowels pattern as weak and strong:

	Underlying	Inserted
$\mu$	V	V

# Representational Models: Short vowels

- Both underlying and inserted vowels pattern as weak and strong:
  - Excrescent and epenthetic vowels highlight necessity for more fine grained representations for inserted segments (Gafos 2002, Hall 2006)

	Underlying	Inserted
$\mu$	V	V

# Representational Models: Short vowels

- Both underlying and inserted vowels pattern as weak and strong:
  - Excrescent and epenthetic vowels highlight necessity for more fine grained representations for inserted segments (Gafos 2002, Hall 2006)
  - Weak underlying vowels highlight necessity for more fine-grained representations of underlying segments:
    - Tonal patterns in San Miguel el Grande Mixtec (Trommer & Zimmerman 2018)
    - Harmony triggers in Rejang and Classical Manchu (Smith 2017)

	Underlying	Inserted
$\mu$	V	V

# Representational Models: Short vowels

- Both underlying and inserted vowels pattern as weak and strong:
  - Excrescent and epenthetic vowels highlight necessity for more fine grained representations for inserted segments (Gafos 2002, Hall 2006)
  - Weak underlying vowels highlight necessity for more fine-grained representations of underlying segments:
    - Tonal patterns in San Miguel el Grande Mixtec (Trommer & Zimmerman 2018)
    - Harmony triggers in Rejang and Classical Manchu (Smith 2017)

	Underlying	Inserted
$\mu$	V	V

Super Light	Light	Canonical	Strong
v	vv	vVV	vVVV

- Subsegmental representations capture this strength scale drawing on faithfulness to capture distinctions between underlying and inserted vowels

# Representational Models: Long vowels

- While inserted vowels may typically be weak, long vowels can be inserted
  - Long vowel epenthesis in Axininca Campa (McCarthy & Prince 1993)

	Underlying	Inserted
$\mu\mu$	VV	VV

Super Light	Light	Canonical	Strong
v	vv	vVV	vVVV

# Representational Models: Long vowels

- While inserted vowels may typically weak, long vowels can be inserted
  - Long vowel epenthesis in Axininca Campa (McCarthy & Prince 1993)
- Long vowels vary in moraic structure and bimoraic vowels can differ in strength:

	Underlying	Inserted
$\mu\mu$	VV	VV

Super Light	Light	Canonical	Strong
v	vv	vVV	vVVV

# Representational Models: Long vowels

- While inserted vowels may typically weak, long vowels can be inserted
  - Long vowel epenthesis in Axininca Campa (McCarthy & Prince 1993)
- Long vowels vary in moraic structure and bimoraic vowels can differ in strength:
  - Scottish Gaelic inserted vowels are long but it is contested whether they head a syllable (Hall 2006, Hammond et al. 2014)

	Underlying	Inserted
$\mu\mu$	VV	VV

Super Light	Light	Canonical	Strong
v	vv	vVV	vVVV

# Representational Models: Long vowels

- While inserted vowels may typically weak, long vowels can be inserted
  - Long vowel epenthesis in Axininca Campa (McCarthy & Prince 1993)
- Long vowels vary in moraic structure and bimoraic vowels can differ in strength:
  - Scottish Gaelic inserted vowels are long but it is contested whether they head a syllable (Hall 2006, Hammond et al. 2014)
  - Long vowels don't attract stress Panãra (Schwarz et al. 2019, Lapierre 2019)

	Underlying	Inserted
$\mu\mu$	VV	VV

Super Light	Light	Canonical	Strong
v	vv	vvv	vvvv

# Representational Models: Long vowels

- While inserted vowels may typically weak, long vowels can be inserted
  - Long vowel epenthesis in Axininca Campa (McCarthy & Prince 1993)
- Long vowels vary in moraic structure and bimoraic vowels can differ in strength:
  - Scottish Gaelic inserted vowels are long but it is contested whether they head a syllable (Hall 2006, Hammond et al. 2014)
  - Long vowels don't attract stress Panãra (Lapierre 2019, Schwarz et al. 2019)
    - Both highlight that strength and weight are independent

	Underlying	Inserted
$\mu\mu$	VV	VV

Super Light	Light	Canonical	Strong
v	vv	vvv	vvvv

# Representational Models: Long vowels

- While inserted vowels may typically weak, long vowels can be inserted
  - Long vowel epenthesis in Axininca Campa (McCarthy & Prince 1993)
- Long vowels vary in moraic structure and bimoraic vowels can differ in strength:
  - Scottish Gaelic inserted vowels are long but it is contested whether they head a syllable (Hall 2006, Hammond et al. 2014)
  - Long vowels don't attract stress Panãra (Schwarz et al. 2019, Lapierre 2019)
    - Both highlight that strength and weight are independent
  - In Nanti, syllable weight is dependent on coda, strength, *and* vowel quality, highlighting need for more granularity (Crowhurst & Michael 2005)

	Underlying	Inserted
$\mu\mu$	VV	VV

Super Light	Light	Canonical	Strong
v	vv	vVV	vVVV

# Comparing Representational Models

- Existing binary distinctions provide useful generalizations about some vowel behavior but don't provide a *scale* of strength sufficient for capturing patterns in vowel strength.
- Thus, we propose a q-theoretic scale of strength which is independent from underlying and weight status, instead relying on faithfulness constraints and emergent properties of the grammar to capture these binary distinctions.
  - This captures differences in strength within category for underlying, inserted, bimoraic vowels.
  - Furthermore, it captures strength similarities across category distinctions.

Super Light	Light	Canonical	Strong
v	vv	vvv	vvvv



# **Formalizing the strength scale: Deriving patterns**

# Deriving patterns from the 4-way representation

- This 4-point representational scale gives rise to families of stringent faithfulness and markedness constraints (de Lacy 2004).
- These constraints generate correct typological predictions and model language-internal phenomena in a principled manner.

# Deriving patterns from the 4-way representation

- **Faithfulness:** Weaker vowels are more likely to delete, inserted vowels are more likely to be weak
  - $\text{Dep}(vvvv)$ ,  $\text{Dep}(vvvv,vvv)$ ,  $\text{Dep}(vvvv,vvv,vv)$ ,  $\text{Dep}(vvvv,vvv,vv,v)$

# Deriving patterns from the 4-way representation

- **Faithfulness:** Weaker vowels are more likely to delete, inserted vowels are more likely to be weak
  - $\text{Dep}(vvvv)$ ,  $\text{Dep}(vvvv,vvv)$ ,  $\text{Dep}(vvvv,vvv,vv)$ ,  $\text{Dep}(vvvv,vvv,vv,v)$
- **Markedness:** how markedness interacts with these scales depends on the phonetic dimension grounding the markedness constraint
  - Ability to be stressed: stronger better than weaker
    - \* $\text{Stress}(v)$ , \* $\text{Stress}(vv,v)$ , \* $\text{Stress}(vvv,vv,v)$ , \* $\text{Stress}(vvvv,vvv,vv,v)$

# Deriving patterns from the 4-way representation

- **Faithfulness:** Weaker vowels are more likely to delete, inserted vowels are more likely to be weak
  - **Dep(vvvv)**, Dep(vvvv,vvv), Dep(vvvv,vvv,vv), Dep(vvvv,vvv,vv,v)
- **Markedness:** how markedness interacts with these scales depends on the phonetic dimension grounding the markedness constraint
  - Ability to be stressed: stronger better than weaker
    - \***Stress(v)**, \*Stress(vv,v), \*Stress(vvv,vv,v), \*Stress(vvvv,vvv,vv,v)
  - Ability to be a syllable nucleus: stronger better than weaker
  - Ability to exhibit contrast: stronger better than weaker
  - Susceptibility to assimilation: weaker more susceptible than stronger

# Constraint families & Faithfulness: Epenthesis

Panãra cluster epenthesis: Superlight *v* arises between two Cs

- \*ComplexOnset is weighted highly enough to cause epenthesis of the weakest vowel, but stringent constraints ensure that nothing stronger epenthesizes

# Constraint families & Faithfulness: Epenthesis

Panãra cluster epenthesis: Superlight *v* arises between two Cs

- \*ComplexOnset is weighted highly enough to cause epenthesis of the weakest vowel, but stringent constraints ensure that nothing stronger epenthesizes

Weights		2.0	1.0	1.0	1.0	1.0	Total
	/krɔ/	*CompOns	DEP(vvvv)	DEP(vvvv,vvv)	DEP(vvvv,vvv,vv)	DEP(vvvv,vvv,vv,v)	
a.	krɔ	-1	0	0	0	0	-2
☞ b.	k(ɔ)rɔ	0	0	0	0	-1	-1
c.	k(ɔɔ)rɔ	0	0	0	-1	-1	-2
d.	k(ɔɔɔ)rɔ	0	0	-1	-1	-1	-3
e.	k(ɔɔɔɔ)rɔ	0	-1	-1	-1	-1	-4

# Constraint families & Faithfulness: Epenthesis

Panãra final epenthesis: Light (vv) arises word finally to avoid C#

- A markedness constraint against word-final superlight vowels weighted highly enough to ensure that nothing weaker or stronger than (vv) is epenthesized

# Constraint families & Faithfulness: Epenthesis

Panāra final epenthesis: Light vv arises word finally to avoid C#

- A markedness constraint against word-final superlight vowels weighted highly enough to ensure that nothing weaker or stronger than (vv) is epenthesized

Weights		3.0	2.0	1.0	1.0	1.0	1.0	TOTAL
	/tɛp/	*CODA	*v#	DEP(vvvv)	DEP(vvvv,vvv)	DEP(vvvv,vvv,vv)	DEP(vvvv,vvv,vv,v)	
a.	tɛp	-1	0	0	0	0	0	-3
b.	tɛp(i)	0	-1	0	0	0	-1	-3
☞ c.	tɛp(ii)	0	0	0	0	-1	-1	-2
d.	tɛp(iii)	0	0	0	-1	-1	-1	-3
e.	tɛp(iiii)	0	0	-1	-1	-1	-1	-4

# Constraint families & Faithfulness: Epenthesis

- In languages like Axininca Campa, where long vowels *are* epenthesized, the DEP constraint family would be the same, but a word minimality constraint (as in McCarthy & Prince 1993) would outweigh the entire family of Dep(vvv).

# Constraint families & Markedness: Quality

- Weaker vowels are less likely to have large contrastive inventories than stronger vowels.
  - In Panāra, light (vv) vowels have a single quality: [i]
  - Could be captured with the same technology used to capture the fact that unstressed vowels in some languages have a smaller inventory

# Constraint families & Markedness: Quality

- Weaker vowels are less likely to have large contrastive inventories than stronger vowels.
  - In Panãra, light (vv) vowels have a single quality: [i]
  - Could be captured with the same technology used to capture the fact that unstressed vowels in some languages have a smaller inventory
- Weaker vowels are more prone to assimilation
  - In Panãra, the quality of superlight (v) vowels is dependent on the surrounding segments
  - Could be captured with ABC+Q technology (Inkelas & Shih 2016).

# Conclusions

- We have motivated the existence of a four-point scale of segment strength, defined by subsegmental quantity
- All four points are utilized in languages like Panãra
- This four-point scale is useful for explaining cross-linguistic patterns related to segment strength (epenthesis, quality, stressability, etc)
- The scale allows us to capture more behaviors than systems utilizing only binary moraic weight and underlying vs. insertedness distinctions.

# References

- Bellik, Jennifer. 2018. An acoustic study of vowel intrusion in Turkish onset clusters. *Laboratory Phonology: Journal of the Association for Laboratory Phonology*, 9(1), 16.
- Crowhurst, Megan & Lev Michael. 2005. Iterative footing and prominence-driven stress in Nanti (Kampa). *Language* 81(1): 47-95.
- de Lacy, Paul. 2004. Markedness conflation in Optimality Theory. *Phonology* 21(2). 145– 199.
- Gafos, A. 2002. A grammar of gestural coordination. *Natural Language and Linguistic Theory*, 20, 269-337.
- Garvin, K., Lapierre, M., & Inkelas, S. 2018. A Q-theoretic approach to distinctive subsegmental timing. *Proceedings of the 2018 Linguistic Society of America*.
- Gafos, A. I. 2002. A grammar of gestural coordination. *Natural Language & Linguistic Theory*, 20(2), 269–337.
- Hall, Nancy E. 2006. Cross-linguistic patterns of vowel intrusion. *Journal of Phonology* 23(3), 387-429.
- Hammond, Michael, Warner, Natasha, Davis, Andréa, Carnie, Andrew, Archangeli, Diana & Fisher, Muriel 2014. Vowel insertion in Scottish Gaelic. *Phonology* 31. 123–153.
- Inkelas, Sharon & Stephanie S. Shih. 2017. Looking into Segments. In Karen Jesney, Charlie O'Hara, Caitlin Smith & Rachel Walker (eds.), *Proceedings of the 2016 Annual Meeting on Phonology*. Washington, DC: Linguistic Society of America.
- Inkelas, Sharon & Stephanie S. Shih. 2016a. Re-representing phonology: consequences of Q Theory. In Christopher Hammerly & Brandon Prickett (eds.), *Proceedings of the North East Linguistic Society* 46. GLSA Publications.
- Inkelas, Sharon.; and Stephanie S. Shih. 2013. *Contour segments and tones in (sub)segmental Agreement by Correspondence*. University of Manchester, UK.

# References

- Jannedy, Stephanie. 1994. Gestural Phrasing as an Explanation for Vowel Devoicing in Turkish. *Ohio State University Working Papers in Linguistics* 45, 6-84.
- Lapierre, Myriam. 2019. A Phonological Analysis of Panāra. Ph.D. Qualifying Paper. University of California, Berkeley.
- McCarthy, J. & A. Prince. 1993. Prosodic morphology: Constraint interaction and satisfaction.
- Morén, Bruce T. 2000. Distinctiveness, Coercion and Sonority: A Unified Theory of Weight. University of Maryland, College Park dissertation.
- Ryan, Kevin. 2018. VV > VC > V for Stress: Coercion vs. Prominence. *Linguistic Inquiry*.1-16.
- Schwarz, M., Lapierre, M., Garvin, K., & Inkelas, S.. 2019. Recent Advances in Q Theory: Segment Strength. Proceedings of the 2019 LSA.
- Shih, Stephanie S. & Sharon Inkelas. 2014. A subsegmental correspondence approach to contour tone (dis)harmony patterns. Kingston, J., C. Moore-Cantwell, J. Pater & A. Rysling (eds.), Proceedings of the 2013 Meeting on Phonology, Linguistic Society of America, Washington, D.C.
- Shih, Stephanie S. & Sharon Inkelas. 2019. Autosegmental aims in surface optimizing phonology. *Linguistic Inquiry* 50, 137-196. doi:[https://doi.org/10.1162/ling\\_a\\_00304](https://doi.org/10.1162/ling_a_00304)
- Smith, C. 2017. Harmony triggering as a contrastive property of segments. Proceedings of the 2016 AMP.
- Trommer, Jochen. & Eva Zimmermann. 2018. The strength and weakness of tone: A new account to tonal exceptions and tone representations. UC Berkeley Phonetics & Phonology Forum.

# Markedness Scales: Stress

**Panāra:** \*Stress(v), \*Stress(v, vv) >> Align-R(Stress) >> \*Stress(v, vv, vvv), \*Stress(v, vv, vvv, vvvv) correctly predicts that stress will fall on the rightmost full or strong vowel.

- a. /ku:per/ → [ku:.'pe.ri] (*proper name*)
- b. (k k k) (u u u u) . '(p p p) **e e e** . (r r) (i i)

**[tableau from PHREND slides]**

# Markedness Scales: Stress

- **Turkish:** higher ranking of Align-R(Stress) predicts final vowel stress even on inserted or underlying weak vowels (e.g. devoiced high vowels (Jannedy 1994)).
- [add tableau]