Young infants' sensitivity to vowel harmony is independent of language experience
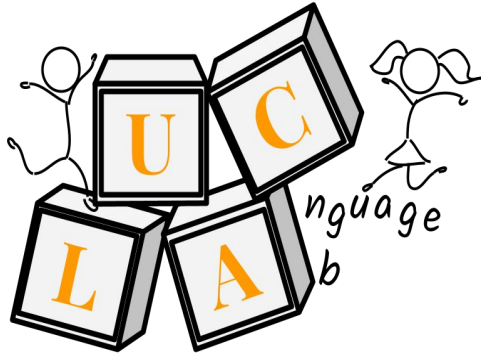
Elizabeth Solá-Llonch & Megha Sundara
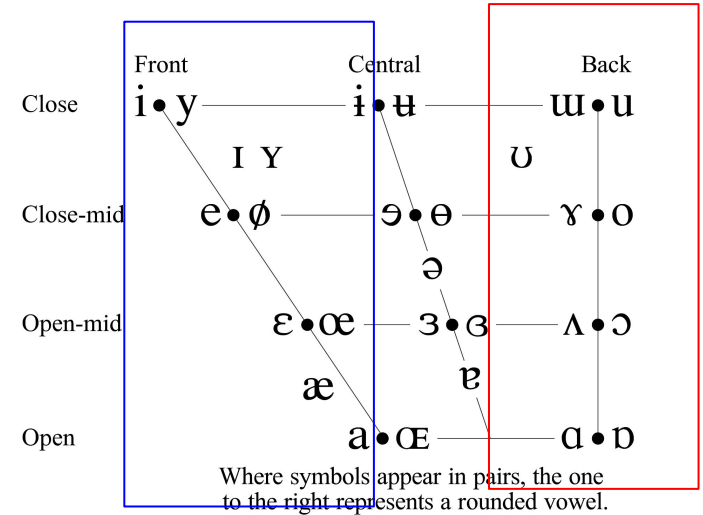UCLA

The UCLA Phonetics Lab

Thank you!

- Babies & families in LA

- Lab managers: Minqi Liu; Rosie Mejia; Victoria Mateu; Gissell Alvarado

- UCLA Language Acquisition Lab undergrad RAs

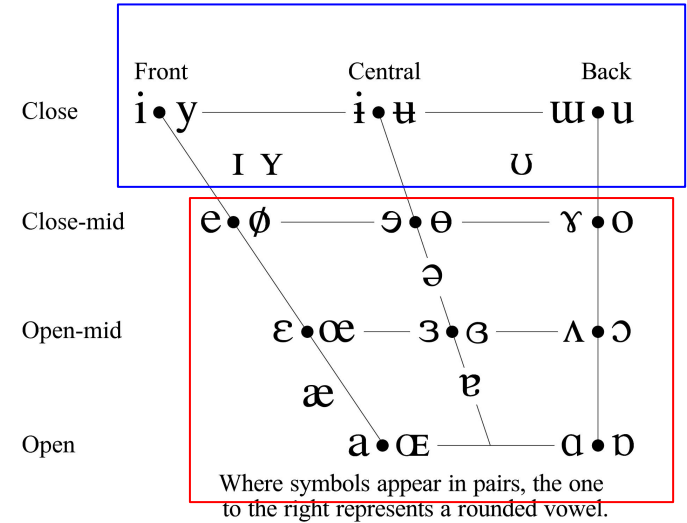- NSF BCS-2214017 (w/ Connor Mayer at UC Irvine)

Vowel harmony

- Vowel harmony: a typologically common pattern where vowels within some domain (e.g., word) are similar across some dimension

- Examples

  - Turkish backness harmony: [zengin] & [josun]

Where symbols appear in pairs, the one to the right represents a rounded vowel.

© 2018 IPA   Typefaces: Doulos SIL (metatext); Doulos SIL, IPA Kiel, IPA LS Uni (symbols)

Vowel harmony

- Vowel harmony: a typologically common phonotactic pattern where vowels within some domain (e.g., word) are similar across some dimension

- Examples

  - Turkish backness harmony: [zengin] & [josun]

  - Kisa (Bantu) height harmony: /-tsom-il-a/ → [-tsom-**e**l-a]

Where symbols appear in pairs, the one to the right represents a rounded vowel.

© 2018 IPA   Typefaces: Doulos SIL (metatext); Doulos SIL, IPA Kiel, IPA LS Uni (symbols)

Sensitivity to native language phonotactics

Timeline of infant sensitivity to native language phonotactics, based off meta-analysis on ~2000 infants learning 8 languages (Sundara et al. 2022):

- < 8 months, infants are sensitive to:

  - Vowel harmony, one kind of a non-adjacent vowel dependency

- At 8-10 months, infants become sensitive to:

  - Local dependencies

  - Non-adjacent consonant dependencies

- > 10 months, infants become sensitive to:

  - Arbitrary non-adjacent vowel dependencies

Puzzle: why early sensitivity to vowel harmony?

- Non-adjacent dependencies are difficult to learn for adults, infants and animals (Wilson et al. 2020)

- In AGL studies, dependencies between vowels are more difficult to learn (e.g., Bonatti et al. 2005; Newport & Aslin 2004)

- Besides harmony, non-adjacent vowel dependencies are learned later than all other phonotactic patterns (after 10 months)

Why early sensitivity to vowel harmony?

- **Experience account:** infants learning vowel harmony languages have extensive experience with harmony in their input

- **Perceptual salience account:** learning of non-local dependencies is aided by cues that group elements together perceptually (see Wilson et al. 2020 for a review)
  - e.g., backness harmony dependency: same backness feature and similar F2 values

Questions

1. Is experience necessary to detect vowel harmony?

   a. At 4-months, for infants with <u>no</u> experience with vowel harmony (n = 56)

2. What is the role of experience in detecting vowel harmony?

   a. At 4 months, for infants hearing vowel harmony languages (n = 26)

   b. At 8 months, for infants with <u>no</u> experience with vowel harmony (n = 26)

Is experience necessary to detect vowel harmony?

Is experience necessary?

- Test 4-month-olds' preference for harmonic vs disharmonic words
  - Experiment 1A: height harmony (n = 28)
  - Experiment 1B: backness harmony (n = 28)
- Participants
  - Monolingual and bilingual infants
  - No experience with a language with vowel harmony
    - Mostly hearing English, Spanish, Russian or Mandarin

Central Fixation procedure

- Completely infant-controlled preference experiment
  - Infant looks towards TV, audio stimulus plays
  - Infant looks away for 2+ seconds, trial ends
  - Looking time taken as proxy measurement for listening time
- 2 familiarization trials with music
- 12 test trials; harmonic vs. disharmonic items
- Looking time data analyzed with Bayesian mixed effects models
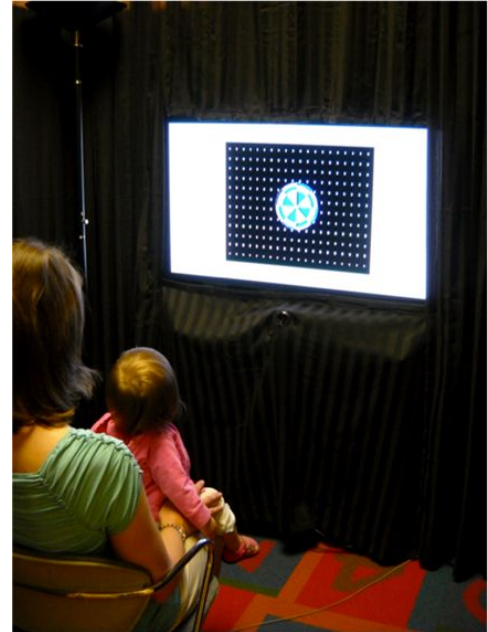
Stimuli

Height harmony

HARMONIC		DISHARMONIC	
High-High	Mid-Mid	High-Mid	Mid-High
	bode		bodi
budi	bedo	bude	bedu
	pote		poti
puti	peto	pute	petu

Backness harmony

HARMONIC		DISHARMONIC	
Front-Front	Back-Back	Front-Back	Back-Front
bide	bodu		bodi
bedi		bedu	bude
pite	potu		poti
peti		petu	pute

- 6 harmonic and 6 disharmonic CVCV nonce words
- Only two consonant frames: *b-d-* and *p-t-*
- 4 vowels: [i, e, o, u]

Stimuli

- Words were recorded in a soundbooth by a female native English speaker using infant-directed speech (IDS), with a declarative (HL) intonation pattern.

- Matched for:

  - Duration

  - F0: average minimum and maximum; range; mean
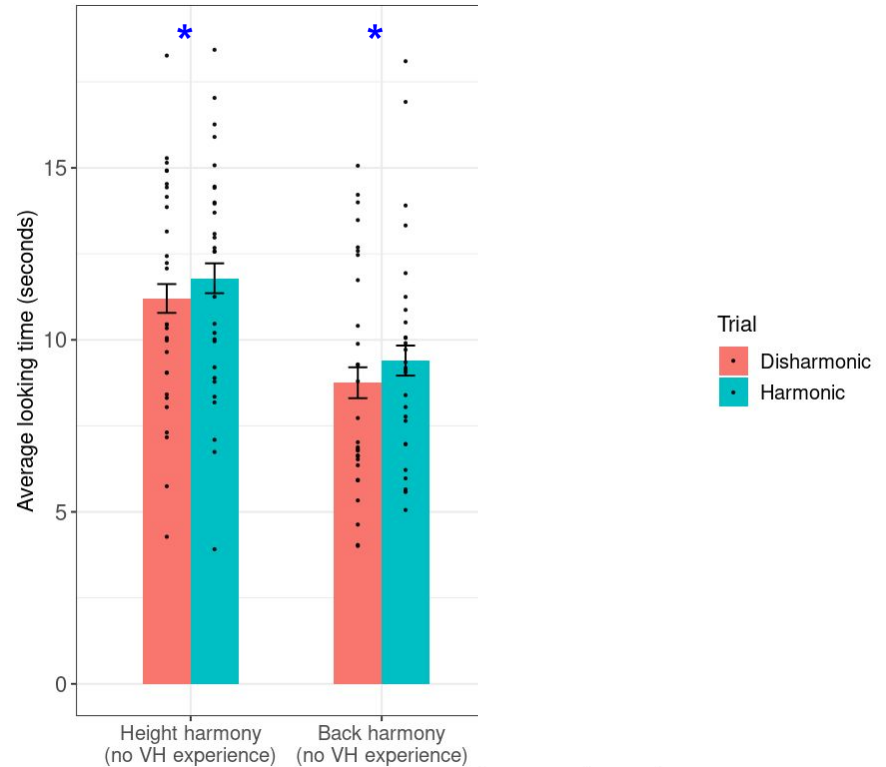
- Normalized intensity to ~ 78 dB

1A: 4-month-olds prefer words with height harmony

Even without experience, 4-month-olds prefer harmonic over disharmonic trials
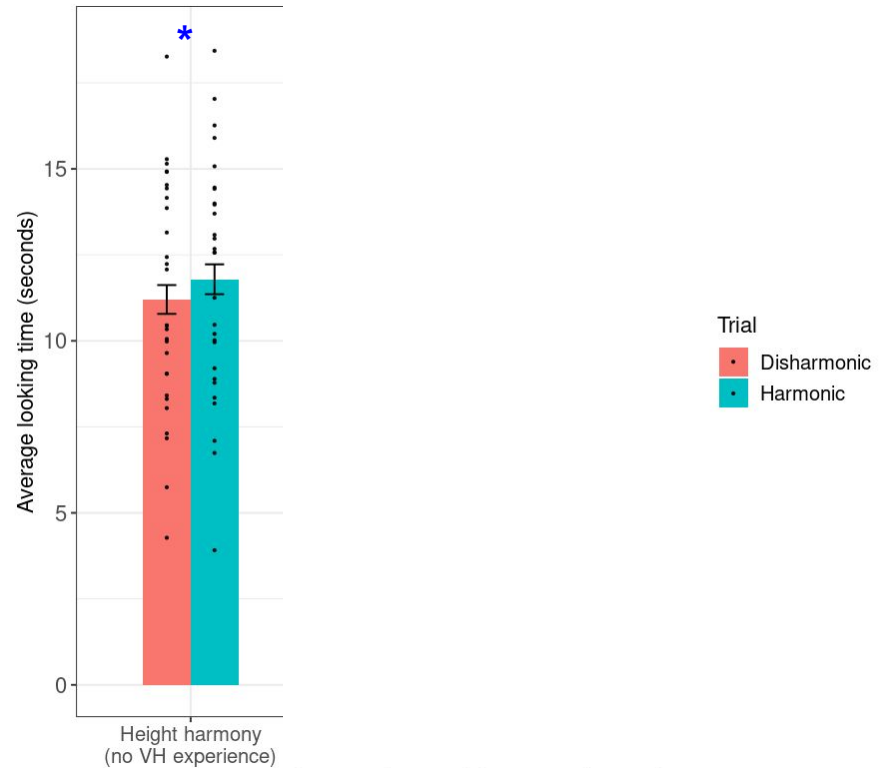
1B: 4-month-olds prefer words with backness harmony

Even without experience, 4-month-olds
prefer harmonic over disharmonic trials

Questions

1. Is experience necessary to detect vowel harmony?

2. What is the role of experience in detecting vowel harmony?
    a. At 4 months, for infants hearing vowel harmony?

    b. At 8 months, for infants with no experience with vowel harmony?

Questions

1. Is experience necessary to detect vowel harmony?

   ⇐ No, 4-month-olds without VH experience are sensitive to VH

2. What is the role of experience in detecting vowel harmony?
   a. At 4 months, for infants hearing vowel harmony?

   b. At 8 months, for infants with no experience with vowel harmony?

What is the role of experience in detecting vowel harmony?

Unpacking the role of experience

Question 2: What is the role of experience in detecting vowel harmony?

    a. At 4 months, for infants hearing vowel harmony…

        i. e.g., babies learning languages like Turkish where every word is harmonic

        ii. Does experience facilitate detection of vowel harmony?

    b. At 8 months, for infants not hearing vowel harmony…

        i. e.g., babies learning languages like English and Spanish

   ii. Do they maintain or lose sensitivity to vowel harmony?

How does experience affect 4-month-olds?

- Test 4-month-olds' preference for harmonic vs disharmonic words
  - Experiment 2A: <u>backness harmony</u> (n = 26)
- Participants
  - Monolingual and bilingual infants
    - Experience with **any language that has harmony**
      - Extent of experience with VH language(s) ranges from 1-100%
    - Languages like Turkish, Korean, Hungarian, Mongolian, Kazakh, Farsi
      - Evidence of VH in these languages ranges from marginal (Korean) to extensive (Turkish)

2A: 4-month-olds with experience prefer disharmony

With experience, 4-month-olds have a switch in preference

- Disharmonic > Harmonic
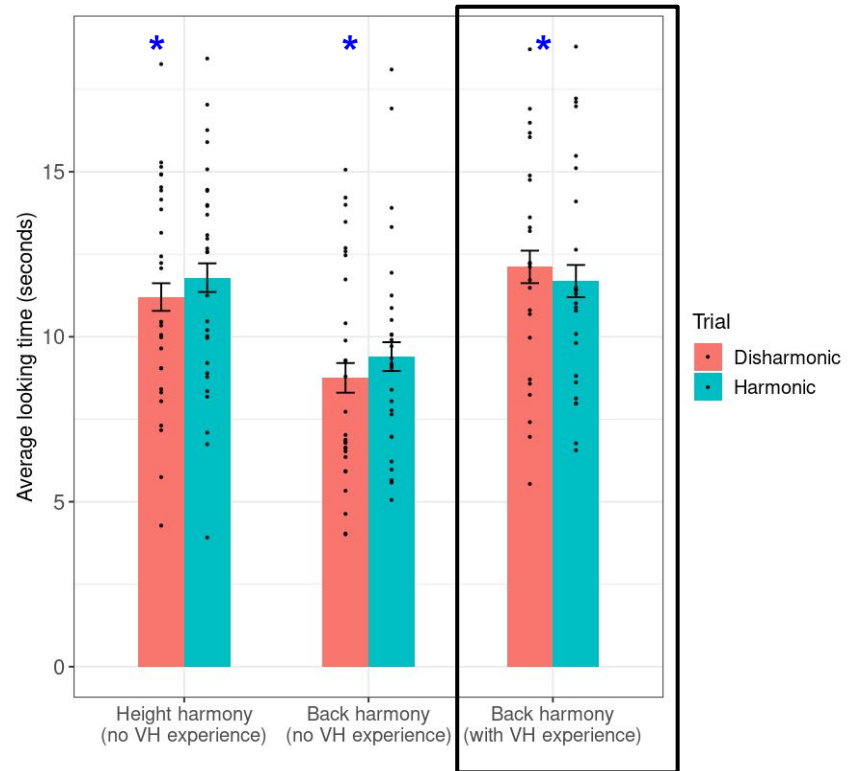
Questions

1. Is experience necessary to detect vowel harmony?

   ⇐ No, 4-month-olds without VH experience are sensitive to VH

2. What is the role of experience in detecting vowel harmony?
   a. At 4 months, for infants hearing vowel harmony?

   b. At 8 months, for infants with no experience with vowel harmony?

Questions

1. Is experience necessary to detect vowel harmony?

   ⇐ No, 4-month-olds without VH experience are sensitive to VH

2. What is the role of experience in detecting vowel harmony?
   a. At 4 months, for infants hearing vowel harmony?

      ⇐ 4-month-olds' sensitivity to VH is facilitated with experience (based on extensive experience with VH→novelty preference)
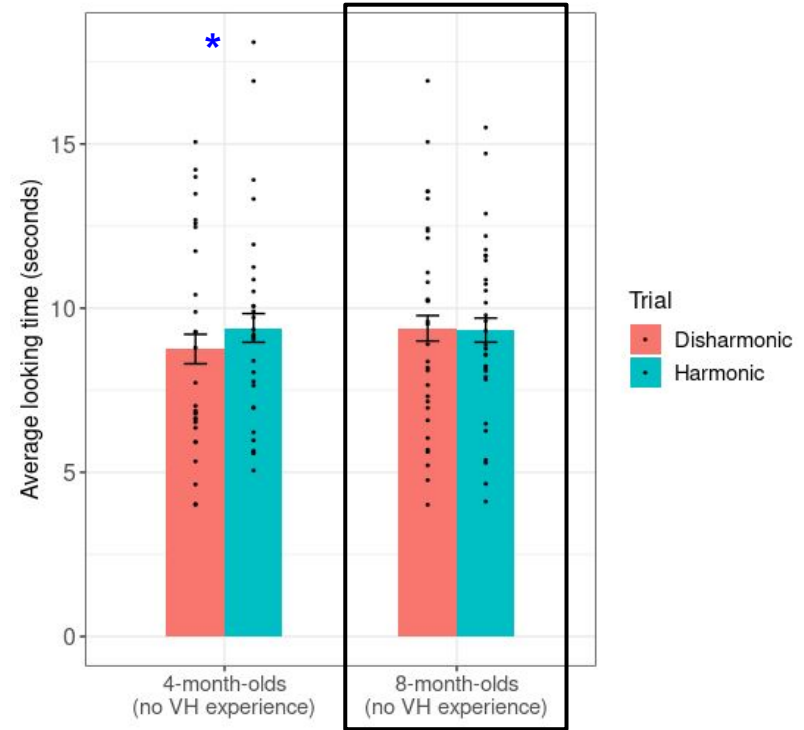
   b. At 8 months, for infants with no experience with vowel harmony?

How does a lack of experience affect 8-month-olds?

- Test 8-month-olds' preference for harmonic vs disharmonic words

  - Experiment 2B: <u>backness harmony</u> (n = 26)

- Participants (same background as experiment 1)

  - Monolingual and bilingual infants

    - No experience with a language with vowel harmony

    - Mostly hearing English, Spanish, Russian, or Mandarin

2B: 8-month-olds without experience have no preference

Without experience, 8-month-olds do not show sensitivity to vowel harmony

Questions

1. Is experience necessary to detect vowel harmony?

    ⇐ No, 4-month-olds without VH experience are sensitive to VH

2. What is the role of experience in detecting vowel harmony?
    a. At 4 months, for infants hearing vowel harmony?

        ⇐ 4-month-olds with experience have a more developed sensitivity to VH

    b. At 8 months, for infants not hearing vowel harmony?

Questions

1. Is experience necessary to detect vowel harmony?

   ⇐ No, 4-month-olds without VH experience are sensitive to VH

2. What is the role of experience in detecting vowel harmony?
   a. At 4 months, for infants hearing vowel harmony?

      ⇐ 4-month-olds with experience have a more developed sensitivity to VH

   b. At 8 months, for infants not hearing vowel harmony?

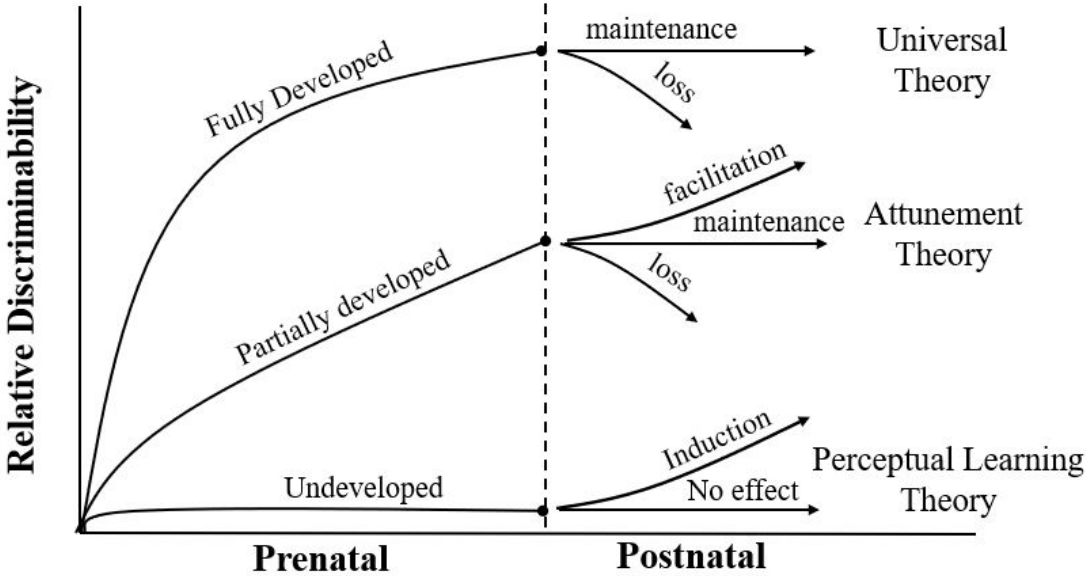   ⇐ 8-month-olds without experience lose sensitivity to VH

Development of sensitivity to VH in context
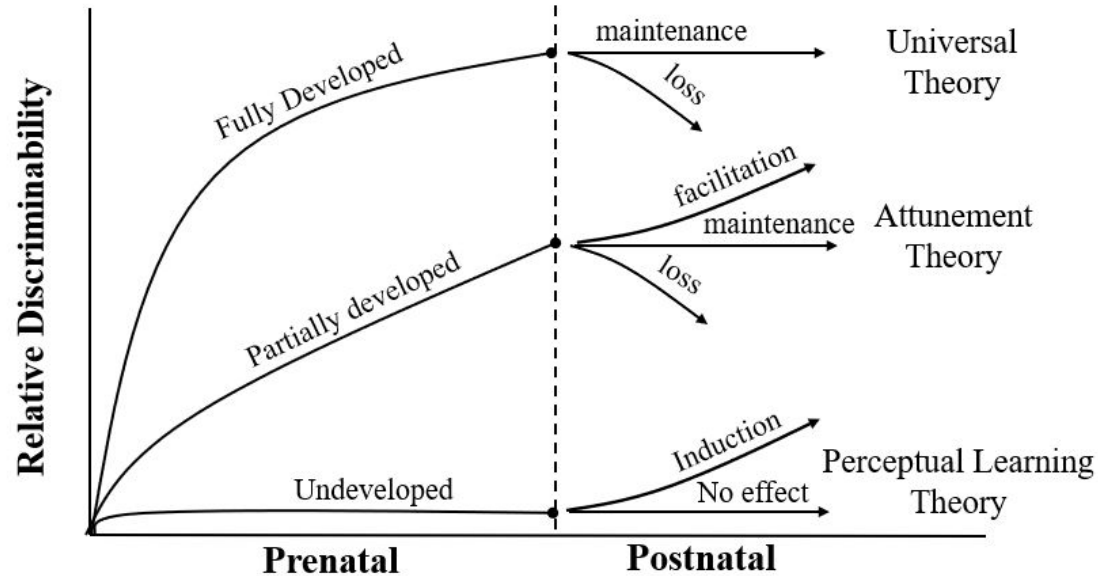
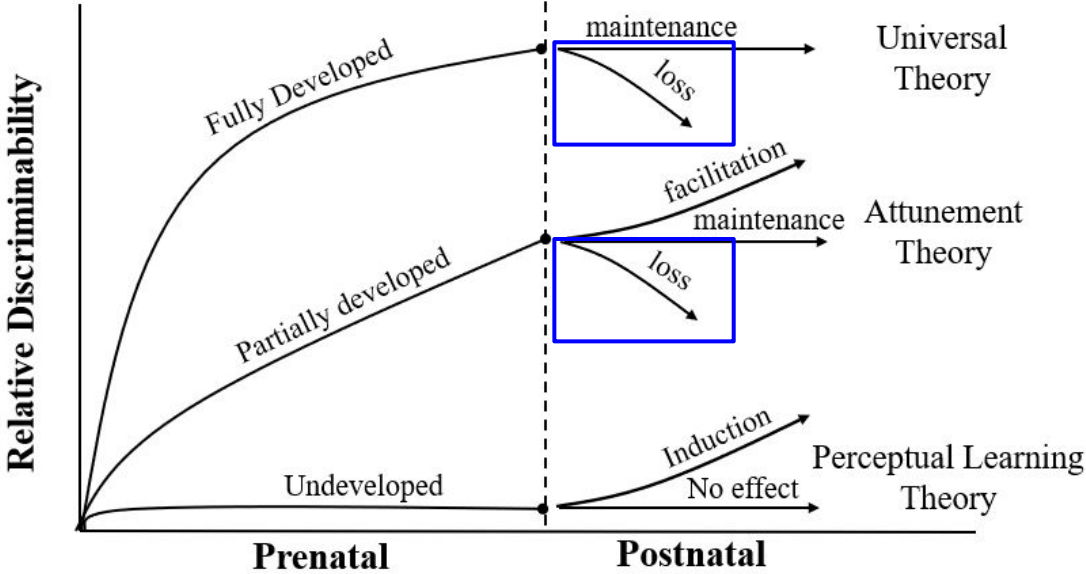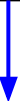Aslin & Pisoni, 1980 based on Gottlieb (1974)

Development of sensitivity to VH in context

Aslin & Pisoni, 1980 based on Gottlieb (1974)

With no experience, 4-month-olds are sensitive to VH

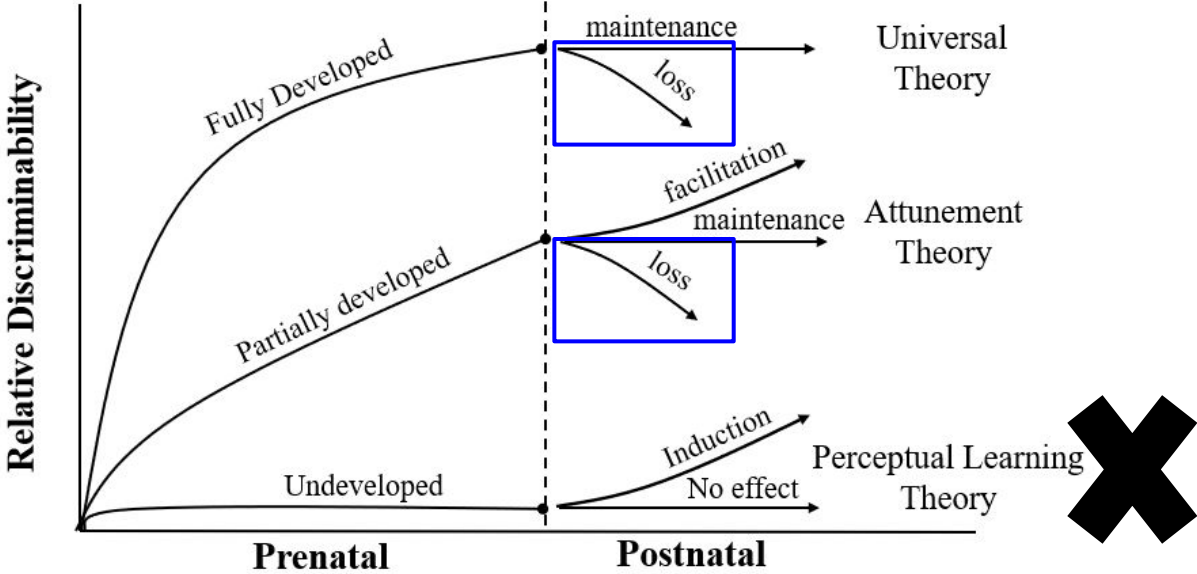# Development of sensitivity to VH in context

Aslin & Pisoni, 1980 based on Gottlieb (1974)

With no experience, 4-month-olds are sensitive to VH

With no experience, 8-month-olds show a **loss** of sensitivity

Development of sensitivity to VH in context

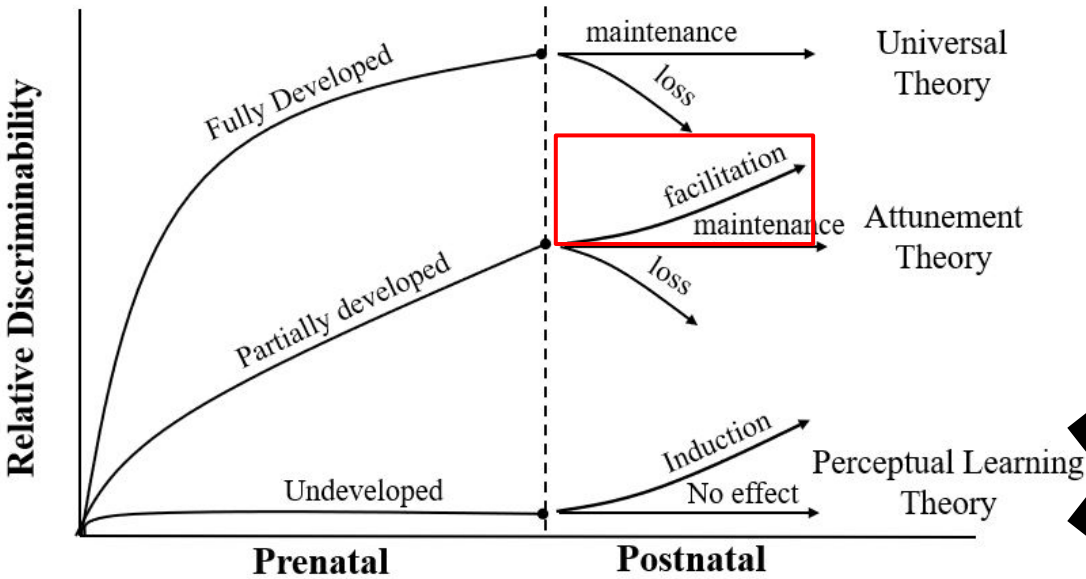Aslin & Pisoni, 1980 based on Gottlieb (1974)

With no experience, 4-month-olds are sensitive to VH

With no experience, 8-month-olds show a **loss** of sensitivity

Development of sensitivity to VH in context

Aslin & Pisoni, 1980 based on Gottlieb (1974)

With no experience, 4-month-olds are sensitive to VH

With VH experience, 4 month olds' sensitivity was facilitated

Development of sensitivity to VH in context
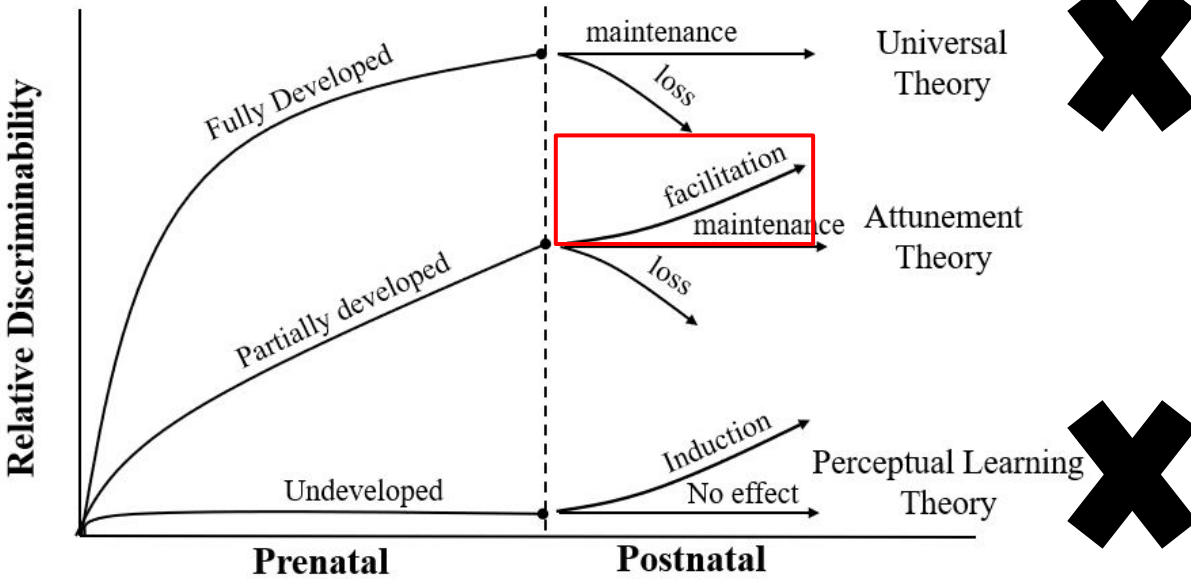

Aslin & Pisoni, 1980 based on Gottlieb (1974)

With no experience, 4-month-olds are sensitive to VH

With VH experience, 4 month olds' sensitivity was facilitated
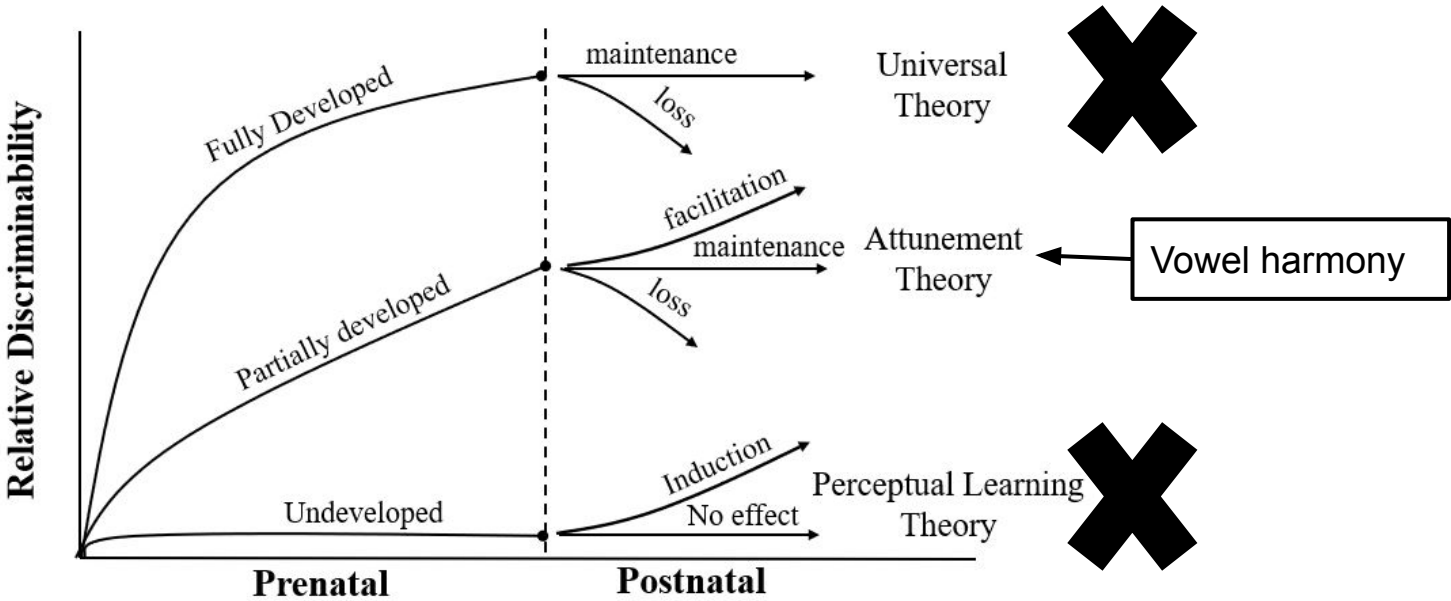
Development of sensitivity to VH in context

Aslin & Pisoni, 1980 based on Gottlieb (1974)

Implications

- Not consistent with a distinct vowel tier (e.g., Aksënova et al. 2020)

  - Could explain early acquisition of vowel harmony results (e.g., Hohenberger et al. 2016)

  - Cannot explain late acquisition of arbitrary non-adjacent vowel dependencies like in Hebrew templates (Segal et al. 2015)

- Not consistent with sensitivity to VH being bootstrapped from sensitivity to adjacent dependencies (e.g., assumed in Belth 2020)

  - Sensitivity to vowel harmony: 4-months

  - Sensitivity to adjacent dependencies: 8- and 10-months

- Early sensitivity to vowel harmony relies on domain-general perceptual mechanisms

Future directions

We are in the process of investigating infant sensitivity to other harmony patterns:

- Rounding harmony

- Advanced Tongue Root harmony (w/ Paul Omane, Natalie Boll-Avetisyan & Titia Benders, U of Potsdam)

More gradient approach to vowel harmony:

- Corpus analysis of infant directed speech to index the extent of vowel harmony in 6 different languages (Sundara, Xu, Solá-Llonch, Doucette, & White, in progress)

References

- Aksënova, A., Rawski, J., Graf, T., & Heinz, J. 2020. The computational power of harmony. *Oxford Handbook of Vowel Harmony*, Oxford University Press, under review.
- Aslin, R. N. &, Pisoni, D. B. 1980. Some developmental processes in speech perception. In G. H. Yeni-Komshian, J. Kavanagh, & C. A. Ferguson (Eds.), *Child phonology, 2: Perception* (pp. 67–96). New York: Academic Press.
- Aslin, R. N., Werker, J. F., & Morgan, J. L. 2002. Innate phonetic boundaries revisited (L). *The Journal of the Acoustical Society of America, 112*(4), 1257-1260.
- Belth, C. 2020. A Learning-Based Account of Local Phonological Processes. *Phonology*.
- Hohenberger, A., Altan, A., Kaya, U., Tuncer, Ö. K., & Avcu, E. 2016. Sensitivity of Turkish infants to vowel harmony. *The acquisition of Turkish in childhood, 20*, 29.
- Mayer, C., Kondur, A., & Sundara, M. 2022. UCI Phonotactic Calculator (Version 0.1.0) [Computer software]. https://doi.org/10.5281/zenodo.7443706
- Mintz, T. H., Walker, R. L., Welday, A., & Kidd, C. 2018. Infants' sensitivity to vowel harmony and its role in segmenting speech. *Cognition, 171*, 95-107.
- Segal, O., Keren‑Portnoy, T., & Vihman, M. 2015. Infant recognition of Hebrew vocalic word patterns. *Infancy, 20*(2), 208-236.
- Sundara, M., Zhou, Z. L., Breiss, C., Katsuda, H., & Steffman, J. 2022. Infants' developing sensitivity to native language phonotactics: A meta-analysis. *Cognition, 221*, 104993.
- Van Kampen, A., Parmaksiz, G., van de Vijver, R., Höhle, B., Gavarró, A., & Freitas, M. J. 2008. Metrical and statistical cues for word segmentation: The use of vowel harmony and word stress as cues to word boundaries by 6-and 9-month-old Turkish learners. *Language acquisition and development: Proceedings of GALA 2007*, 2007, 313-324.
- Wilson, B., Spierings, M., Ravignani, A., Mueller, J. L., Mintz, T. H., Wijnen, F., ... & Rey, A. 2020. Non‑adjacent dependency learning in humans and other animals. *Topics in cognitive science, 12*(3), 843-858.