Revisiting the role of prosody in early language acquisition

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Outline

- Part I: Intonation has a role in language discrimination

- Part II: Do English-learning infants have a trochaic bias in early word segmentation?

PART I:
LANGUAGE DISCRIMINATION

Newborns discriminate languages

- Early research
  - Native vs. non-native languages (Bahrick & Pickens, 1988; Mehler et al., 1988)
    - Based on familiarity with and recognition of their native language

- More recently
  - Discriminate some language pairs even when unfamiliar with both (Nazzi et al., 1998)
    - Based on infants’ sensitivity to prosody, “*specifically the rhythmic, timing differences*” between languages

What is rhythm?

- Languages traditionally divided into 3 rhythm classes (Pike, 1945; Abercrombie, 1967)
  - Stress-timed (E.g. English, Dutch, German)
  - Syllable-timed (E.g. Spanish, French, Italian)
  - Mora-timed (E.g. Japanese, Telugu, Kannada)

- Languages within rhythm classes share syntactic (Mehler & Christophe, 2000), phonological (Dauer, 1983) and acoustic-phonetic characteristics (Ramus et al., 1999; Low et al., 2000)

Rhythm class: Acoustic-phonetic bases

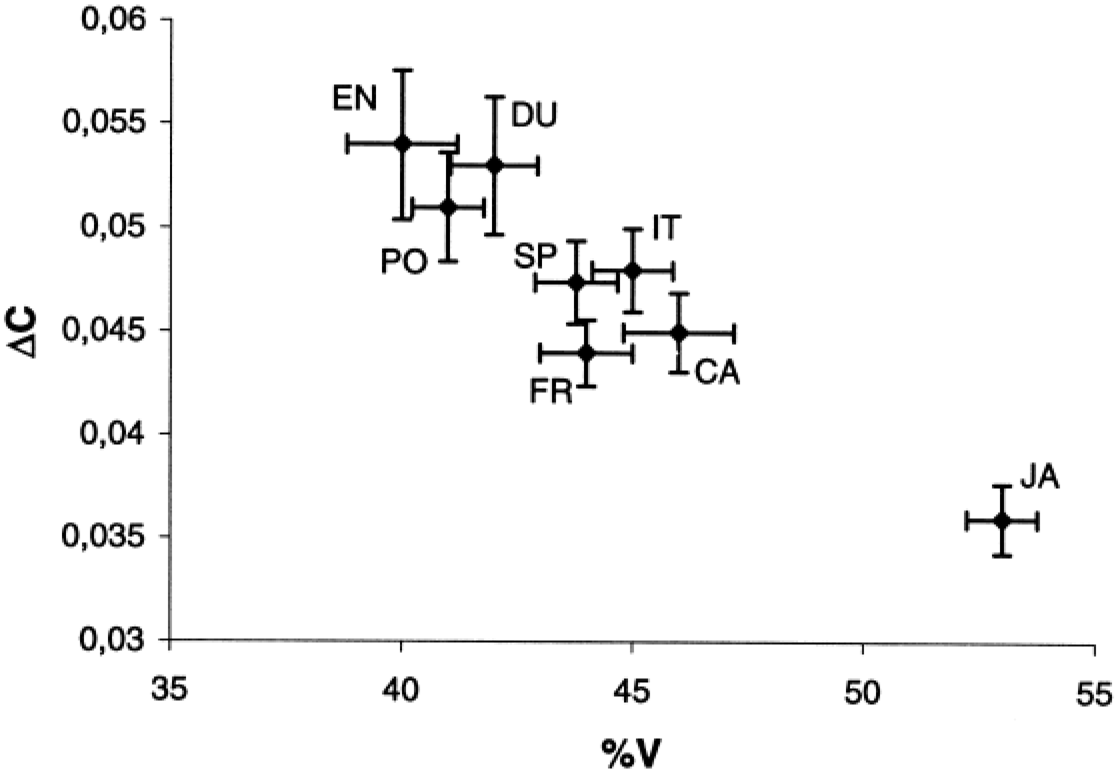


Fig. 1. Distribution of languages over the (%V, ΔC) plane. Error bars represent ± 1 standard error.

Ramus, Nespor & Mehler, 1999

Rhythm divorced from intonation

- …the rhythm-based language discrimination hypothesis (R hypothesis), stems from evidence that newborns are sensitive to prosody, that is, the overall properties of utterances such as intonation and rhythm. The R hypothesis states that infants extract prosodic, and *more specifically, rhythmic properties of sentences* [italics added] and that they sort sentences into a small number of classes or sets based on *rhythmic, timing properties* [italics added]. (Nazzi et al., 1998, p. 757)

Part I: Language discrimination

- English learners' discrimination of English vs. German (joint work with Chad Vicenik)
  - Intonation sufficient to distinguish between rhythmically similar languages.
  - Adult listeners attend to intonation to distinguish them
  - Infants fail to discriminate when intonation is removed

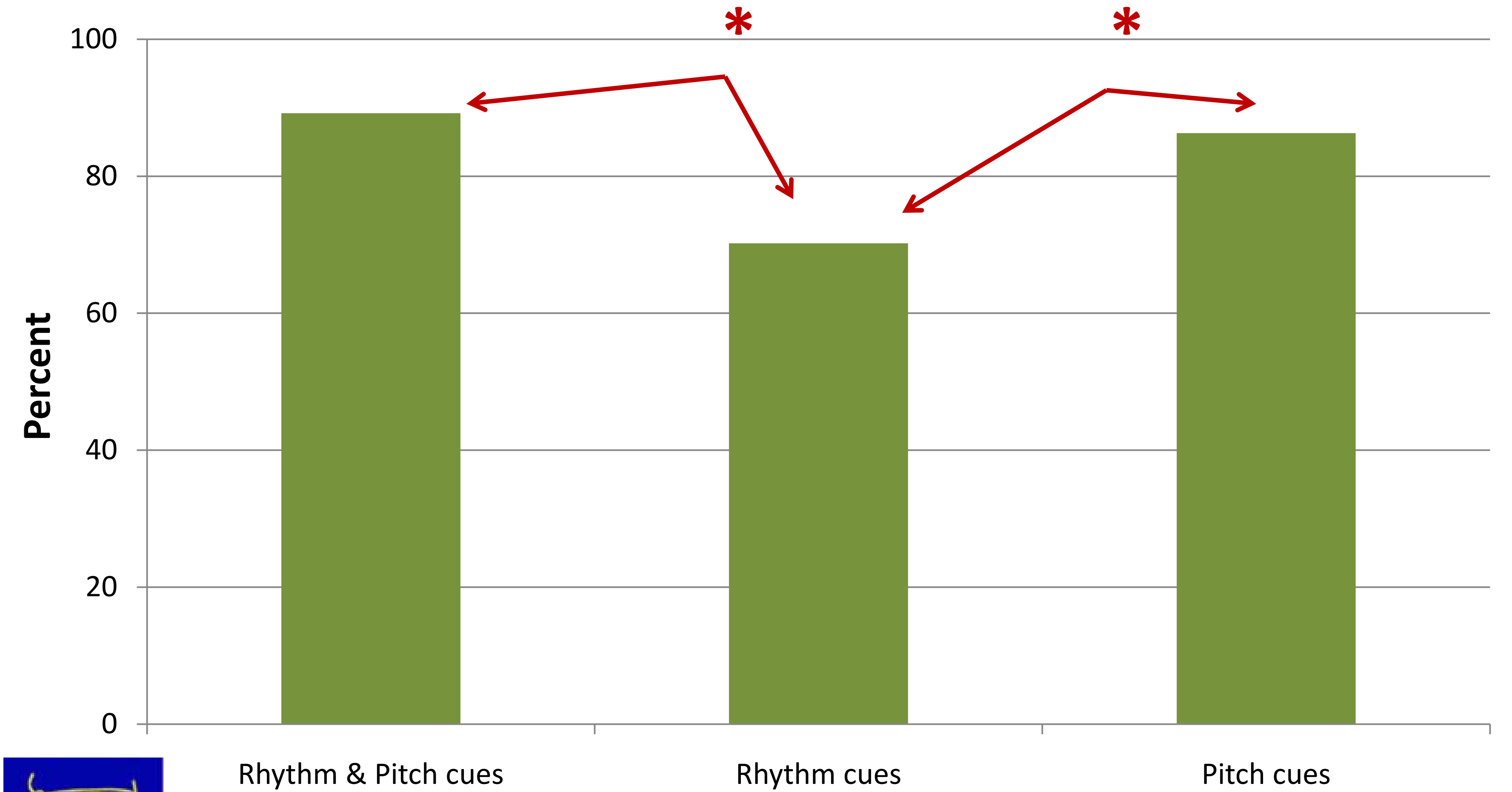
Method

- Stimuli
  - 8 female speakers each
  - 20 sentences per speaker
  - Adult-directed speech
  - Sentences based on the Nazzi et al., 2000 stimuli

What's in the input?

- Acoustic analysis
  - Rhythm measures
    - 11 measures
      - %S, ΔO, ΔS, VarcoS, VarcoO, Mean S, Mean O, rPVI S, nPVI S, rPVI O, nPVI O
  - Intonation measures
    - 6 measures
      - Min f0, max f0, mean f0, number of rises, average rise, average slope of f0

Classification using Logistic Regression



Vicenik & Sundara, under review

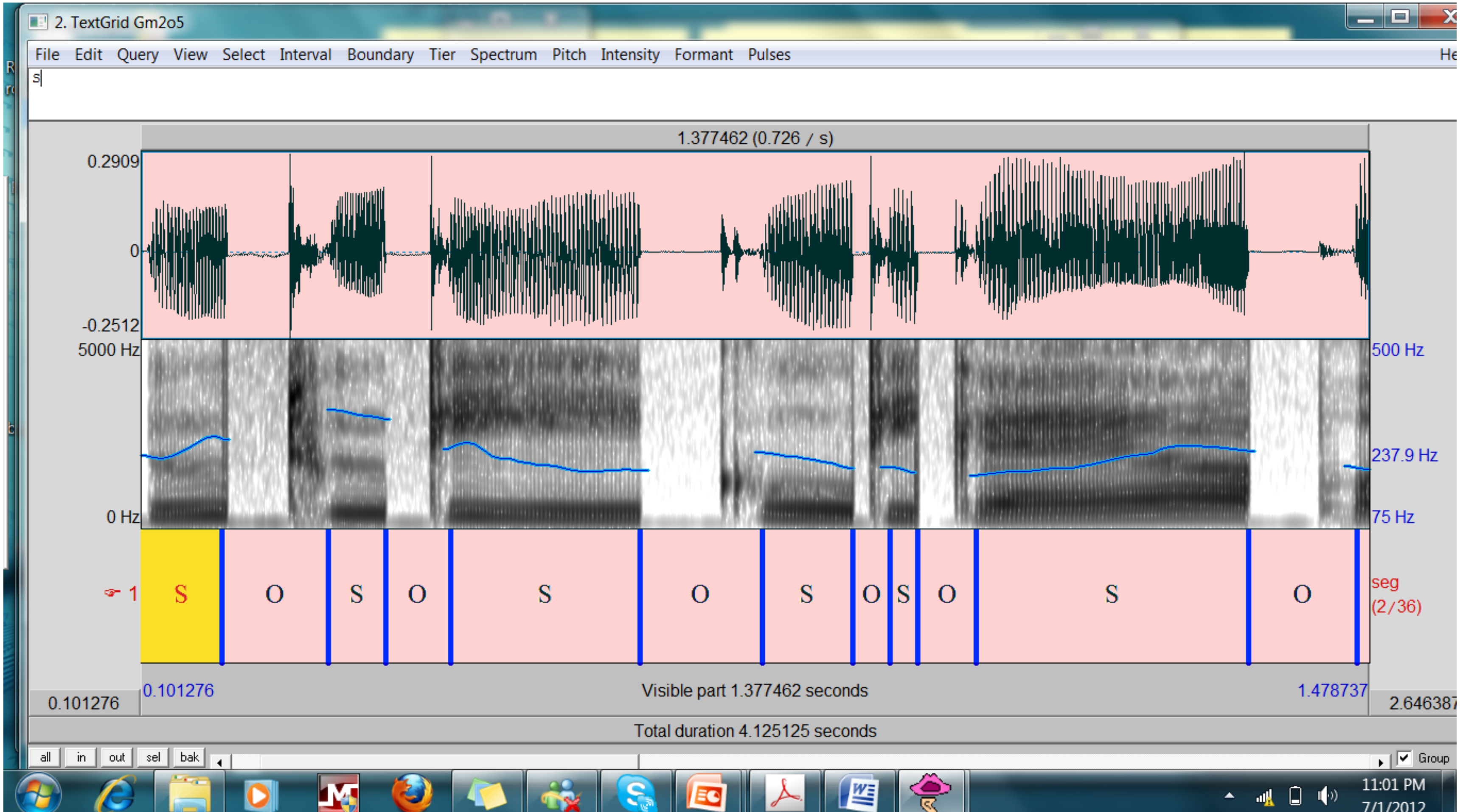
Method

- Stimuli
  - 8 female speakers each
  - 20 sentences per speaker
  - Adult-directed speech
  - Sentences based on the Nazzi et al. stimuli
- Adult listeners
  - N =15 per condition
- 3 conditions
  - Low-pass filtered
  - Rhythm-only
    - ?a?a?a
    - (Sasasa)
  - Intonation only
    - aaaaa

Low-pass filtered

- Cut off at 400 Hz, 50 Hz smoothing
- Sample

Rhythm-only

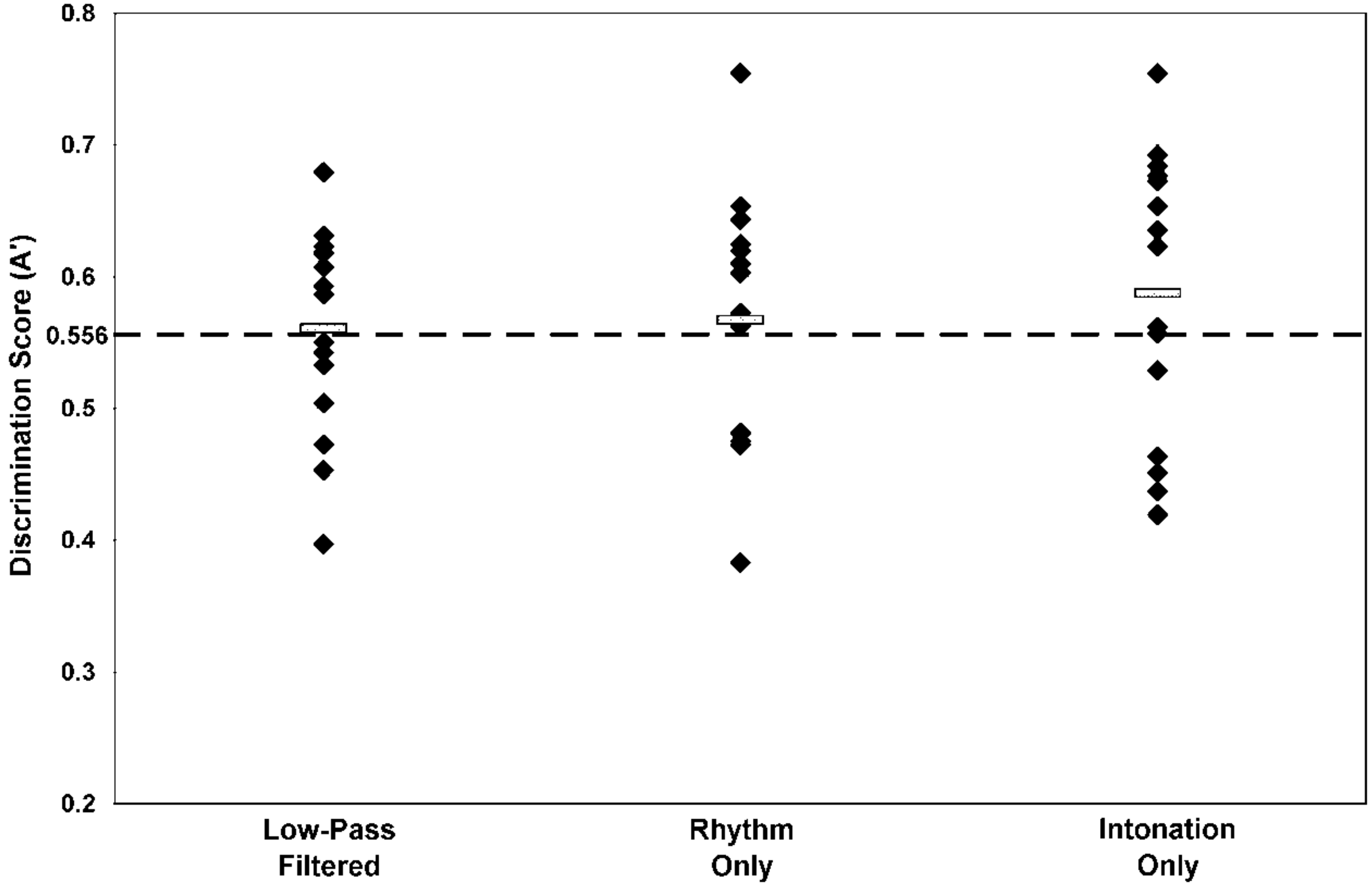


- Sample

Intonation only

- Sample

Adult perception results

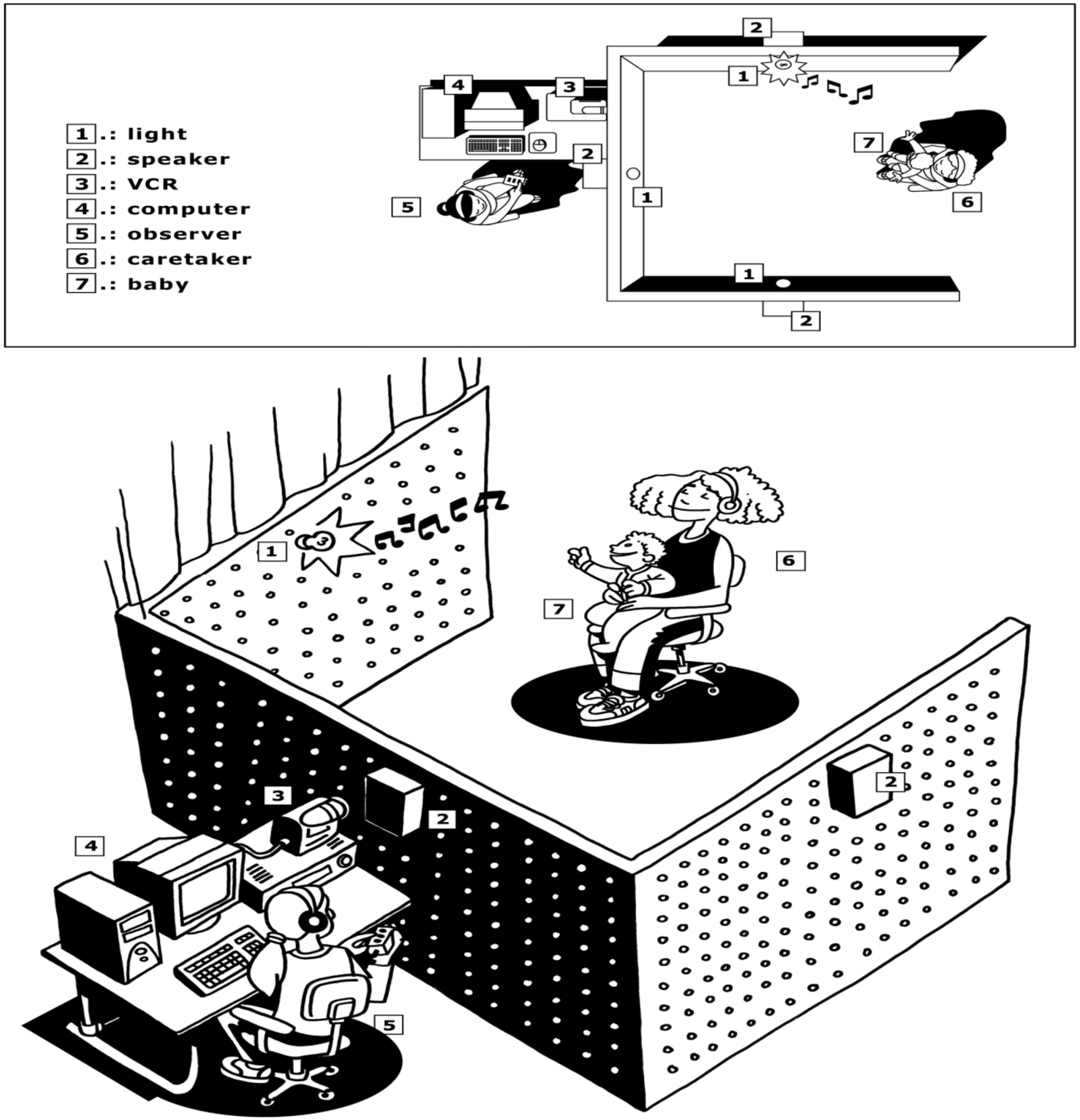


Vicenik & Sundara, under review

Infant listeners

- 5- and 7-month-olds
- Tested using Headturn Preference Procedure (HPP)
  - Identical to Nazzi et al.,'s procedure

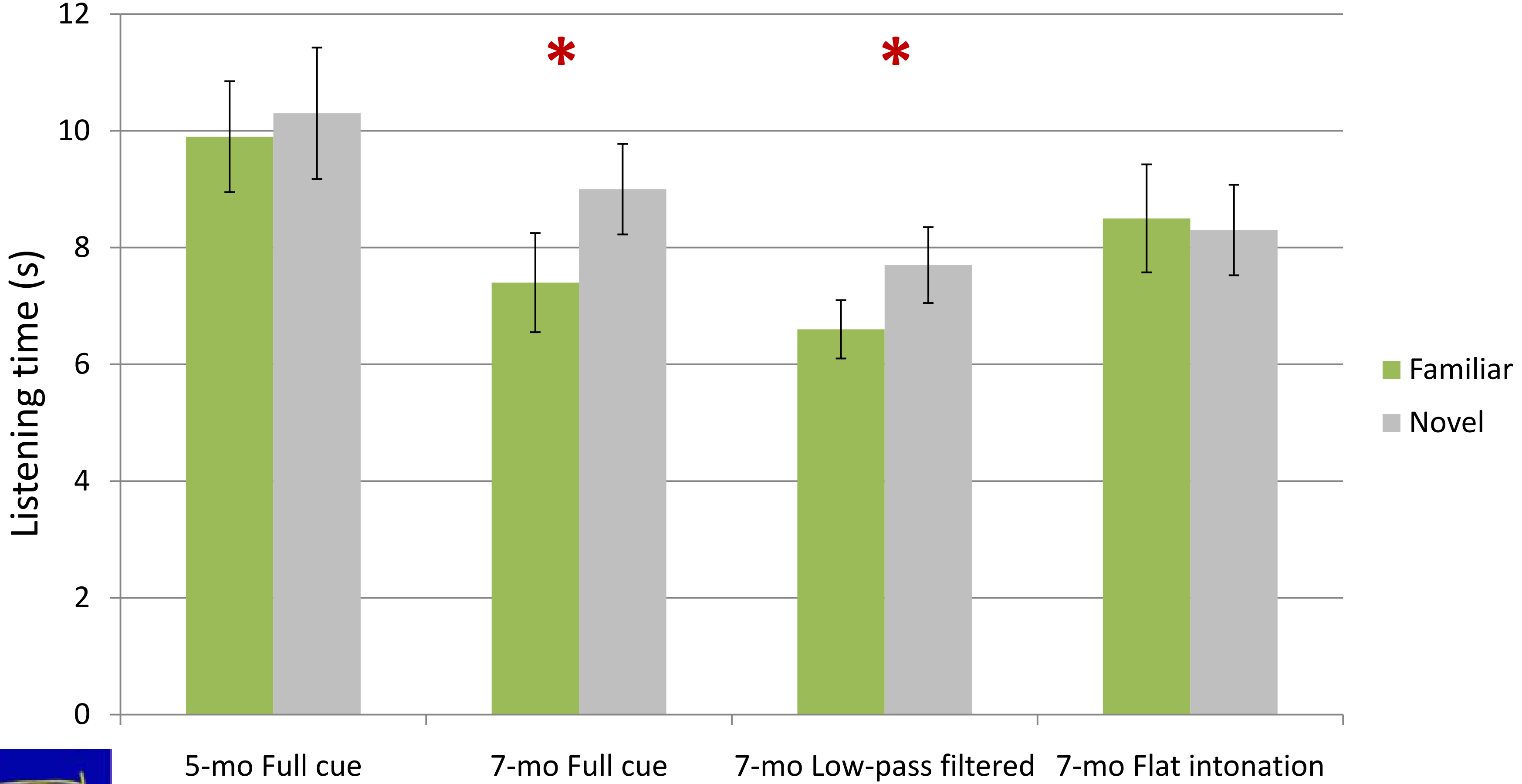
ILUSTRATION OF THE HEAD-TURN PREFERENCE PROCEDURE (HPP)



Design

- Two phases
  - Familiarization phase
    - Either English or German (counterbalanced)
    - 4 passages by 2 different speakers
    - Listen to each passage for at least 20 s (80s total)
  - Test phase
    - 8 trials
    - 4 new passages by 2 new speakers
    - Listening time to familiar and novel language averaged

Infant results



Vicenik & Sundara, under revision

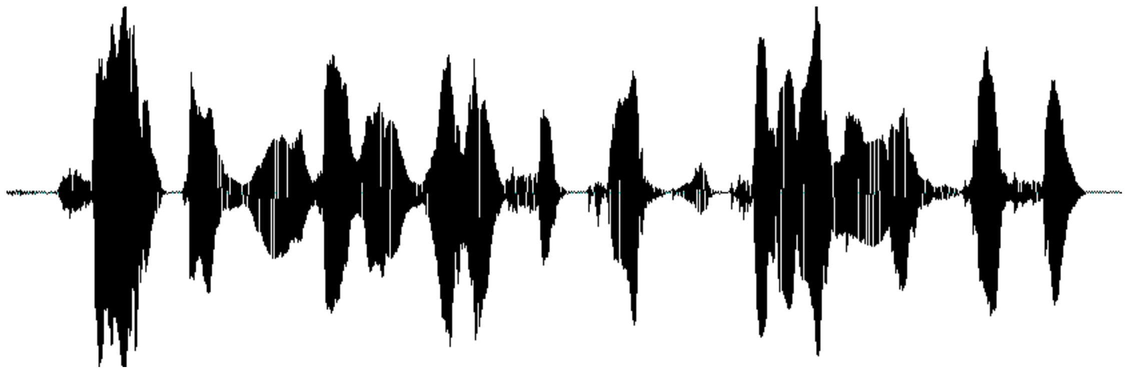
Part I: Language discrimination

- In language discrimination (joint work with Chad Vicenik)
  - Intonation sufficient to distinguish between rhythmically similar languages, English vs. German.
  - Adult listeners attend to intonation to distinguish them
  - Infants fail to discriminate when intonation is removed

- Cannot ignore the role of intonation in language discrimination

PART II: WORD SEGMENTATION

The segmentation problem



Timeline of word segmentation

- Studies by Juscyzk and colleagues

- English-learning babies can segment
  - Monosyllabic CVC (e.g., *cup*): 7.5 mo
  - Trochaic bisyllables (Sw, e.g., *doctor*): 7.5 mo
  - Iambic bisyllables (wS, e.g., *guitar*) : 10.5 mo
  - Monosyllabic VC (e.g., *eel*): 16 mo

Trochaic bias

- Matches ambient language prosody
  - Seen in Dutch, and English (Houston et al., 2000), but not Canadian French 8-month-olds (Polka & Sundara, 2012) segment trochees
- Cannot be learned from the distribution of stress for words in isolation
  - Only a minority of 2 syllable utterances in English are trochaic
- "….infants acquire the trochaic parsing bias as a generalization over a ''protolexicon'' of word forms extracted on the basis of the forms relatively high conditional probability and frequency…."
  - Not just frequency

Swingley, 2005

Central idea in Swingley, 2005

- Statistical probability used to cluster bisyllables necessary for the emergence of a trochaic bias

- Support from artificial language learning studies
  - 6- to 7-month-olds weight transitional probability over prosody (Thiessen & Saffran, 2003)
  - 8-, and 11- month-olds weight prosody over transitional probabilities (Johnson & Jusczyk, 2001)

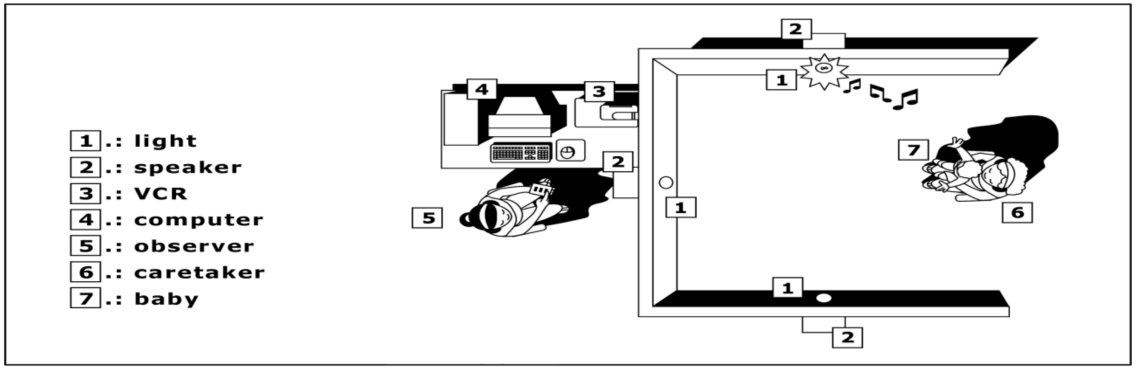
Our prediction

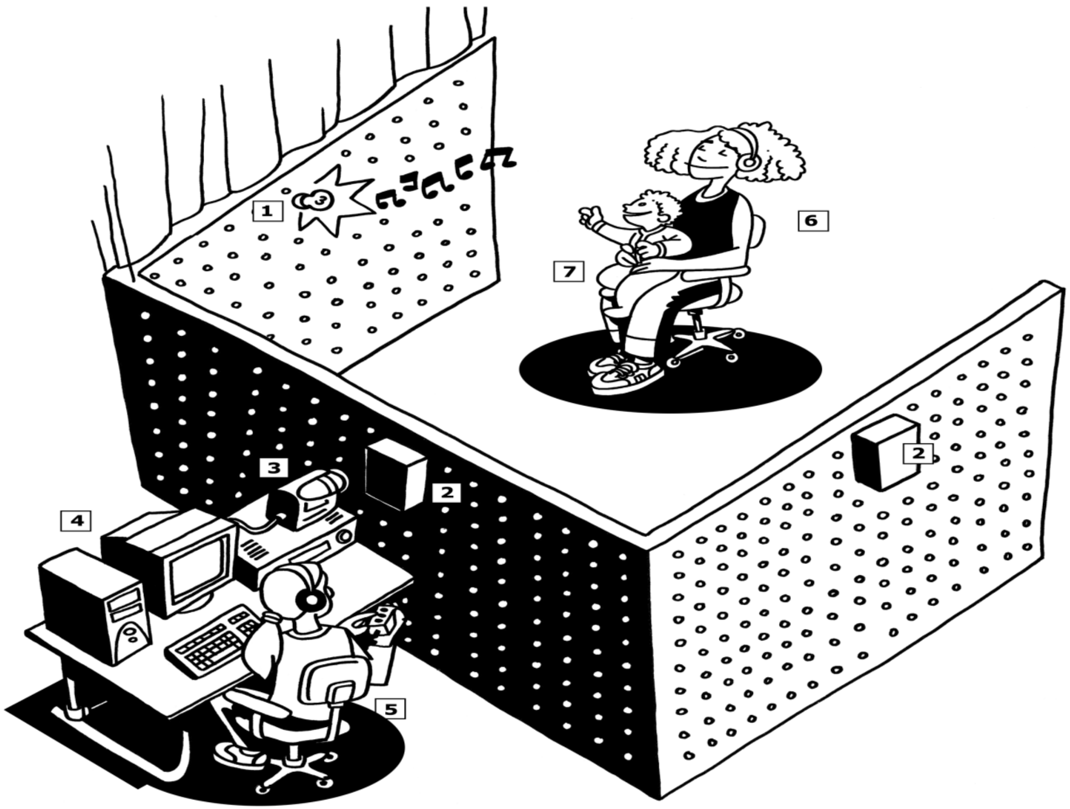
If infants rely on statistical clustering, iambs should not be difficult to segment

Test for sensitivity to iambs

- 6-month-old English-learning infants (n = 8)
- Using the Headturn Preference Procedure
- Tested on *beret*, *device*, *guitar* and *surprise*
  - Familiarized with 2 passages
    - Criteria - 60 s to each passage
  - Tested on all four isolated words

ILUSTRATION OF THE HEAD-TURN PREFERENCE PROCEDURE (HPP)



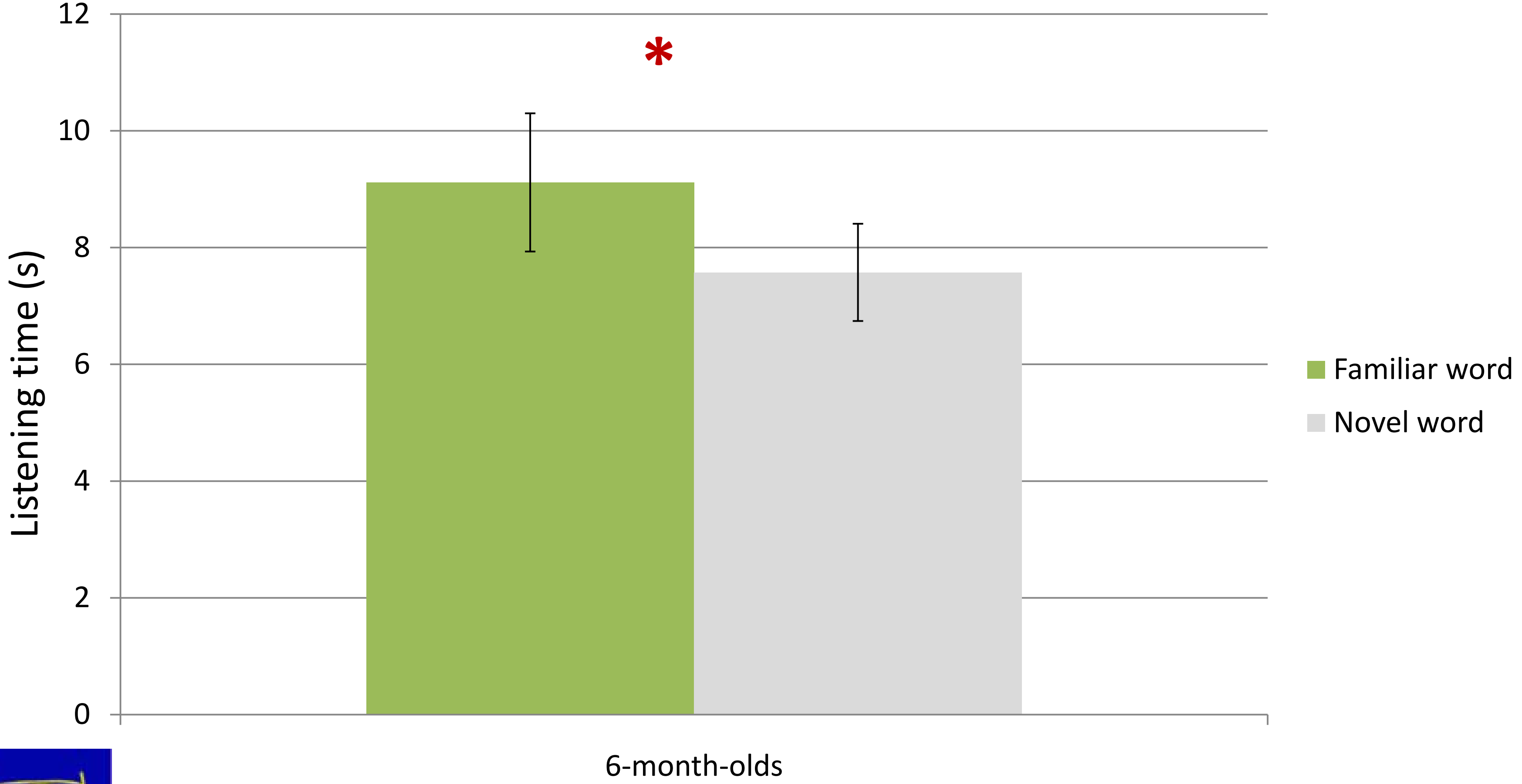


Methods

- Testing with HPP in two stages
  - Familiarization stage
    - E.g. Your device can do a lot. Her device only fixes things. My new red device makes ice cream. The pink device sews clothes……
    - E.g. The big red surprise is for you. The small pink surprise is for Dawn. Your surprise will be fantastic. I think Dawn got the old surprise……..
  - Test stage
    - 2 Familiar word lists
      - device…..device……device….doctor…..
      - surprise….surprise…surprise…..candle….
    - 2 Control / Novel word lists
      - beret…..beret……beret….beret…..
      - guitar….guitar…guitar…..guitar….

Results

Familiar > Novel:
7 out of 8 infants!



Modified timeline of word segmentation

- English-learning babies can segment
  - Iambic bisyllables (wS, e.g., *guitar):* 6 mo
  - Monosyllabic CVC (e.g., *cup*): 7.5 mo
  - Trochaic bisyllables (Sw, e.g., *doctor*): 7.5 mo
  - Iambic bisyllables (wS, e.g., *guitar*): 10.5 mo
  - Monosyllabic VC (e.g., *eel*): 16 mo

- Statistical clustering of bisyllables precedes the trochiac bias

Follow-up

- Do English-learning 6-month-olds rely exclusively on statistical probabilities to segment iambs?

- Use prosodic distribution at utterance boundaries instead (Aslin et al., 1996) ?
  - How do you get boundaries?
    - Prosodic: Intonation
    - Segmental: Preboundary lengthening and post boundary strengthening

Stress at utterance boundaries

Corpus

Stage 1: Extract all input utterance from entire CHILDES corpus

- Utt *U* is **input** to child *c* if *U* uttered when *c* present, not by *c*
- For every child *c* in CHILDES, extract English-only input

Stage 2: Lexical stress

- Custom software: lexical search-and-replace using CELEX
- The **words** are re**placed** by their **stress pat**terns

0 1 0 01 0 0 1 10

Size: 340,000 utts– 2 million wds– 1.5 million syls
Equivalent to about 2 months of language input

Stage 3: De-segment and analyze

- Remove wd bdry's (e.g. 0 1 0 01 0 0 1 10 → 0100100110)
- Statistical properties of resulting distribution

Daland, 2010

Stress at utterance boundaries

Utterance-initial

- Trochees 74340
- Iambs 79529
- (other) (186729)

Utterance-final

- Trochees 88519
- Iambs 98571
- (other) (153508)

Daland, 2010

Follow-up

- Do English-learning 6-month-olds rely exclusively on conditional probabilities to segment iambs?

- Use prosodic distribution at utterance boundaries instead (Aslin et al., 1996) ?
  - How do you get boundaries?
    - Prosodic: Intonation
    - Segmental: Preboundary lengthening and post boundary strengthening

- Use prosodic distribution at phrasal boundaries (Christophe et al., 2008; Daland, 2009)?

Summary & Conclusion

Part I:

- Intonation can be used for language discrimination, even for prosodically similar languages
- Listeners, adults and infants, attend to intonation while discrimination languages

- Need to rethink role of intonation and its interaction with rhythm

Summary & Conclusion

Part II:

- English learning infants can segment iambs at 6-mo

- Need to rethink the contents of protolexicon of infants and the interaction between statistical learning and prosody