On the acquisition of word-stress and intonation: Evidence from early perception

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Introduction

- Early word stress production
  - Dutch children’s first words are often either monosyllabic or disyllabic trochees.
  - This stress pattern is typically realized as a falling pitch contour

\[ \text{\textit{eten} - to eat - Jarmo (1;9.1)} \]
\[ \text{\textit{koetje} - cow -dim - Jarmo (1;9.1)} \]
Introduction (cont’d)

- Word stress continued
  - Dutch also has iambic words like ‘ballon’ and ‘konijn’
  - These words are initially often realized
    - as monosyllabic words with a falling pitch contour
    - or as disyllabic trochees as in ‘ballon’

![Waveform and pitch contour for 'ballon']

Introduction (cont’d)

- Intonation of one-word utterances
  - English infants produce more falling pitch contours than rising contours (Kent & Murray 1982, Kent & Bauer 1985, Snow 2002)
  - So do Dutch infants (informal observation)
  - More statements than questions
  - The falling contour is transcribed as a H*L pitch accent followed by a low boundary tone (L%)
Introduction (cont’d)

▪ Intonation of one-word utterances (cont’d)
  ▪ Why more falls than rises?
    ▪ Falls are physiologically easier to produce
      (Lieberman 1967)
    ▪ Bias in data acquisition
      ▪ The most typical activity in recording sessions is to
        name objects and make statements about objects,
        which are realized via falling contours

'buggy zitten' - to sit (in a) buggy - Jarmo (1;9.1)

Introduction (cont’d)

▪ The issue
  ▪ Both word stress and intonation are largely expressed by
    the same acoustic means (e.g. f0, duration and intensity)
  ▪ Perceptually, the trochaic pattern and the H*L pitch accent
    are very similar
  ▪ The iambic pattern is similar to H*L with a delayed peak

Thus, it is not easy to determine whether the prosodic
prominence attested in children’s production is due to word
stress or sentence accent, or both in early child language
▪ Questions have a very different pattern.

▪ Central question: What is the role of word stress and
sentence accent for word recognition?
Introduction (cont’d)

- Prior work on perception of word stress
  - Jusczyk et al. (1999)
  - By the end of the first year, children are able to segment both trochaic and iambic words in continuous speech after having been familiarized with the words (a head-turn preference procedure). Trochees are segmented earlier than iambs.
  - Vihman et al. (2004)
  - Word recognition is impaired in 11-month-old English infants when trochaic words are mis-stressed (e.g., BAbY presented as baBY) (a head-turn preference procedure).
  - De Bree et al. (2007)
  - The visual fixation paradigm
  - 3-year old Dutch children look longer to correctly stressed words than mis-stressed words.
  - They seem to be more sensitive to word-stress mispronunciations in trochaic words than in iambic words.

Predictions word stress

- Prediction for word stress based on earlier literature
  - Trochaic words are better/earlier recognized than iambs. Possibly more stable results for trochees than iambs.
  - Children will fixate longer to words with correctly produced stress than to words with mispronounced stress.
  - This mispronunciation effect is stronger for trochees than for iambs.
Introduction (cont’d)

- Prior work on perception of contour shapes
  - 6-month-olds are able to perceive changes in contour shapes (fall vs. rise) in infant directed speech (Theaux 2007)
  - 9- to 11-month-olds are able to perceive changes in the contour of brief melodies (Trehub et al. 1987)

Introduction (cont’d)

- Prior work on interpretation of pitch contours
  - 2-month-olds respond to the communicational implications of falling (i.e. soothing) and rising contours (i.e. inviting visual and vocal responses) in female speech (Sullivan & Horowitz 1983)
  - 4-month-olds respond to two different meanings of rising-falling contours (i.e. approving vs. disapproving) in speech-like sounds (i.e. nasalized central vowel) (Papousek et al. 2000)
  - 18-month-olds use intonation to mark a question (Bellugi 1965)
  - 2-year-olds are able to use intonation to distinguish questions from statements when word order is in conflict with intonation (Leder & Egelston 1982)
Predictions intonation

- **Prediction for intonation based on earlier literature**
  - Not so clear
  - Maybe statements (fall) are acquired before questions (rise) (based on production; whether this also holds for perception remains to be seen)
  - If there is a preference for statements, then one hypothesis is that mispronounced intonation is more harmful for statements
  - Questions may preferably have a rising intonation, but in general show more variation in form than statements.
    - A statement with a rising intonation sounds marked.

Aim of current paper

- Tap into young children’s knowledge of word stress and intonation by disentangling the role of word stress and sentence accent in word recognition
- Using the ‘Looking-while-Listening’-procedure
- Younger children from different ages
  - **14-month-olds**
    - beginning word learners
    - still developing their inventory of word stress patterns and intonational contours
  - **24-month-olds**
    - a reasonably large vocabulary (including both trochaic and iambic target words)
    - an adult-like inventory of pitch accents and boundary tones (Chen and Fikkert 2007)
    - Sensitive to the rising question intonation
Predictions

- **Effect of MP-Word Stress and MP-Intonation**: If children have accurate knowledge of both word stress and intonation, they will look at the target word longest when both word stress and intonation are correctly produced and shortest when both are incorrect.

- **Age effect**: 24-month-olds will demonstrate more accurate knowledge of word stress and intonation than the 14-month-olds.

- **Effect of word type (iamb vs. trochee)**: children may show a preference for trochaic word stress regardless of whether it is correct or incorrect produced.

- **Effect of sentence type (Statement vs. question)**: preference for statements?

Experiment

- **Task**
  - Visual fixation task on a Tobii Eyetracker
Experiment

- **Materials**
  - Sentences with known *iambic* and *trochaic* target words, produced with *correct* (CS) or *incorrect* word stress (IS).
  - These words are presented in a carrier sentence requiring a
    - *question intonation* (L*H H%), (e.g. Zie je het konijn? ‘Do you see the rabbit?’)
    - or a *statement intonation* (H*L L%) (e.g. Kijk naar het konijn! ‘Look at the rabbit’)
  - The intonation is either appropriate (CI) for the carrier sentence, or inappropriate (II).
  - In all sentences the pitch accent is realized on the syllable with word stress in the sentence-final noun.

Experiments

- **Variables**
  - Dependent variable: % change in looking time to target word (in various conditions)
  - Independent variables (within subjects)
    - Correct vs. Incorrect word stress
    - Correct vs. Incorrect sentence intonation
  - Between subject variables
    - Word type: trochaic vs. iambic
    - Sentence type: declarative sentence vs. question
    - Age (14mo and 24mo)
  - Fillers included both trochaic and iambic words, and were presented in a declarative sentence if the target words were presented in a question sentence, and vice versa.
Experiments and Participants

- **Four experiments with 14mo**
  - Statement (kijk) – Iamb (konijn, ballon)
    - N=19 (10 boys) – (12 additional children tested, but excluded)
  - Statement (kijk) – Trochee (varken, schommel)
    - N=19 (7 boys) – (14 additional children tested, but excluded)
  - Question (zie) – Iamb
    - N=24 (13 boys) – (9 additional children tested, but excluded)
  - Question (zie) – Trochee
    - N=24 (12 boys) – (10 additional children tested, but excluded)

- **Four experiments with 24mo**
  - Statement (kijk) – Iamb (konijn, ballon)
    - N=20 (7 boys) – (13 additional children tested, but excluded)
  - Statement (kijk) – Trochee (varken, schommel)
    - N=28 (16 boys) – (7 additional children tested, but excluded)
  - Question (zie) – Iamb
    - N=19 (12 boys) – (13 additional children tested, but excluded)
  - Question (zie) – Trochee
    - N=25 (17 boys) – (9 additional children tested, but excluded)

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**Experiment**

- **Examples: CS CI and IS II**

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Analysis

- Time frames used for the analyses

- First, analysis of Looking Time in baseline (i.e. LT to target vs. distractor)
- Second, naming effect
- Third, analysis of mispronunciation effects (MP-Word Stress and MP-Intonation)
Results: 14-month olds – baseline

- No preference to either picture prior to the onset of the target word in the baseline time frame

Results: 14-month olds – MP-word stress

- Increased LT to target in CSCI condition
- But, only in statements, not in questions
- Stronger effect for iambs than for trochees
  - This may be due to word knowledge of the target words
- No recognition of mis-stressed words
Results: 14-month olds – MP-intonation

- For iambs in statements there is an increased LT to target. They are recognized better than trochees.
- Incorrect intonation in statements is hardly influencing word recognition.

Results: 24-month olds – baseline

- No clear preference to either picture prior to the onset of the target word in the baseline time frame.
  - Preference for distractor for iambs, and for target in trochee condition.
Results: 24-mo – MP-word stress

- Significant naming effect for iambs, and almost significant for trochees.
- Significant effect of MP-Word stress effect for iambs: Larger increase in LT to target iambs mispronounced as trochees!
  - This effect is stronger for statements than for questions.

Results: 24-month olds – MP-intonation

- Iambs are better recognized than trochees in both statements and questions.
- Incorrect intonation in statements is hardly influencing word recognition.
Age effects – Word Stress

- **14mo:**
  - Only iambs in statements that are produced with correct stress are recognized. MP Stress effect
- **24mo:**
  - Iambs are recognized in both statements and questions, both in CP- and MP-WordStress
  - Longer LT to iambs produced as trochees!

Back to our predictions word stress

- Trochaic words are better/earlier recognized than iambs. Possibly more stable results for trochees than iambs
  - Iambic words were recognized better
  - This may due to the particular words used
- Children will fixate longer to words with correctly produced stress than to words with mispronounced stress
  - This is indeed the case, particularly for 14mo, but only for iambs
  - 24mo seem to profit from mispronunciation of word stress in iambs
- This mispronunciation effect is stronger for trochees than for iambs
  - Mispronunciations hinder word recognition in 14mo’s for iambs. Trochees are not recognized. Therefore no effect of MP
  - Mispronounced iambs lead to longer LT in 24mo: they may expect words to start with stress and hence have a preference for trochees
- Since 14mo’s do not yet produce iambic, they may not respond to mispronounced word stress.
  - This prediction is not confirmed. They are sensitive to correct stress!
Age effects – Intonation

14mo:
- Only iambs in statements are recognized
- No effect of MP-Intonation in statements
- No recognition of words in questions!

24mo:
- Iambs are recognized in both statements and questions, both in CP- and MP-Intonation
- No effect of MP Intonation

Back to the predictions for intonation

- Statements (fall) are acquired before questions (rise)
  - This is indeed the case: 14mo recognize words in statements before recognizing words in questions
  - 24mo recognize iambs in both statements and questions
- Mispronounced intonation more harmful for statements
  - This prediction is not confirmed; MP-Intonation do not hinder word recognition
Discussion and conclusions

- **Word stress**
  - 14mo only recognize iambs when correctly stressed
  - 24mo have longer LT to iambs in MP Stress condition
  - This suggests that 14mo recognize iambs based on the stressed final syllable. It may be that the initial unstressed syllable is not stored. *Konijn > nijn*
  - For 24mo they have the correct representation of the segmental string of iambs (i.e. both syllables), and word stress on the initial syllable is helpful, rather than hindering
  - Unclear results for trochees. The 24mo only showed a marginal naming effect for trochees

- **Intonation**

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Discussion and conclusions

- **Intonation**
  - 14mo only recognize words (iambs) in statements
  - Statements show less variation in intonation than questions, which ideally may have a rise, but often are produced otherwise
  - No MP Intonation effects attested: word recognition is not hindered by MP Intonation
Discussion and conclusions

- Children appear to have separate knowledge of word stress and sentence-level intonation at the age of 24-month; but not yet robust at 14-month-old
- But, more analyses needed
  - different window of analysis (particularly for 14mo)
  - correlations with word knowledge
  - correlations with vocabulary size
  - ...

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- www.babyresearchcentre.nl