Acoustic Cues Used by Learners of English

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Background
Speech Segmentation Cues

- **Top-down**
  - Pragmatics
  - Syntactic structure
  - Semantics

- **Bottom-up**
  - Metrical prosody
  - Phonotactic constraints
  - Transitional Probabilities
  - Allophonic processes
  - Fine-grained phonetic cues

- In L2 acquisition learners try to **adapt L1 bottom-up cues into the L2**
Segmentation of English sC clusters

• Cross-boundary clusters
  • [ðɪskʰeɪl] - ‘this kale’
  • Shorter /s/-duration
  • Environment for allophonic aspiration

• Word-initial clusters
  • [ðísːkeɪl] - ‘this scale’
  • Longer /s/-duration
  • No environment for allophonic aspiration

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L2 segmentation of sC clusters

• Cue adaptation leads to better L2 segmentation than cue learning (Altenberg, 2005; Ito & Strange, 2009; Shoemaker, 2014)

Cross-boundary: Loose pills

Word-initial: Lou spills

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<th>aspiration contrast</th>
<th>no aspiration contrast</th>
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<tr>
<td>✓</td>
<td>✗</td>
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Current Study
Research Questions

• Using measures of online processing, in what way do the phonological properties of a first language influence segmentation abilities in a second language?

• How is a phonemic contrast not used for word boundary identification adapted as a word boundary cue in a second language?

• How do learners acquire new word boundary cues in a second language?
Languages of Interest

• Mandarin
  • Phonemic aspiration
  • Duration is not a systematic boundary cue
  • No possible word-initial or cross-boundary sC clusters
  • Phonemic $\rightarrow$ allophonic

Aspirated stop: $[\text{p}^h\text{a}]_{51}$ ‘to fear’
Unaspirated stop: $[\text{pa}]_{51}$ ‘father’

• French
  • No systematic aspiration
  • Some level of duration cue used in word-boundary segmentation
  • Both word-initial and cross-boundary sC clusters are possible
  • No contrast $\rightarrow$ allophonic

Word-initial: $[\text{sp}^\text{ʰ}\text{ɔr}^\text{t}^\text{ɪ}^\text{f}]$ ‘athletic’
Cross-boundary: $[\text{s}^\text{i}s\text{p}^\text{j}^\text{ɛ}s]$ ‘six pieces’
Procedure

• Proficiency task
  • Results not reported in this talk

• Production task
  • Familiarize participants with word-picture pairings
  • Collect acoustic data to compare to perception

• Eye-tracking task
  • Used the visual world paradigm
  • Heard words presented in the frame “click on this”
Eye-tracking in the visual world paradigm

- Participants hear spoken language and manipulate objects in a visual world
- Visual world includes a set of object with interesting linguistic properties
- Eye-movements to each object are monitored throughout the task
Why use eye-movements and the visual world paradigm?

• Relatively natural task

• Eye movements generated very fast (within 200ms of stimulus onset)

• Eye movements time-locked to speech

• Subjects are not aware of eye movements

• Fixation probability maps onto lexical activation
Eye-movement analysis

- Target: this scale
- Competitor: this kale
- Filler: a rose
- Filler: a moose
Experimental Design

• Auditory Stimuli
  • Balanced for frequency
  • 10 *table/stable* pairs per place of articulation
  • 60 phonologically unrelated filler items

• Participants
  • 21 native English speakers
  • 20 native Mandarin speakers
  • 7 native French speakers

![Auditory Stimuli Average Durations](image-url)
Results
Production

/s/ duration

Cross-boundary
Word-initial

VOT duration

Cross-boundary
Word-initial

English Mandarin French
Accuracy

Accuracy by Cluster Type

Native English
Native Mandarin
Native French

Cross-boundary
Word-initial
Perception - maximum proportion of fixations

Target Fixations

Competitor Fixations

<table>
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<th>Time (ms) where 0 is onset of /s/</th>
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<td>-750</td>
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Proportion of Fixations

English
Mandarin
French

0
0.2
0.4
0.6
0.8
1

Proportion of Fixations

0
0.2
0.4
0.6
0.8
1

Time (ms) where 0 is onset of /s/
Perception - slope of fixations

Target Fixations

Proportion of Fixations

Time (ms) where 0 is onset of /s/

Competitor Fixations

Proportion of Fixations

Time (ms) where 0 is onset of /s/

English  Mandarin  French
Perception - slope of fixations by language

- **English**: Cross-boundary and Word-initial
- **Mandarin**: Cross-boundary and Word-initial
- **French**: Cross-boundary and Word-initial

![Graphs showing proportion of fixations over time for English, Mandarin, and French languages, with red circles highlighting specific time periods.](image-url)
Perception - crossover point of fixations

- English: 615 ms
- Mandarin: 657 ms
- French: 615 ms
Perception - midpoint of competitor fixations

- **English**
  - Time (ms) where 0 is onset of /s/
  - Proportion of fixations
  - Red circles highlight the midpoint of competitor fixations

- **Mandarin**
  - Time (ms) where 0 is onset of /s/
  - Proportion of fixations
  - Red circles highlight the midpoint of competitor fixations

- **French**
  - Time (ms) where 0 is onset of /s/
  - Proportion of fixations
  - Red circles highlight the midpoint of competitor fixations

Legend:
- **Cross-boundary**
- **Word-initial**
Conclusions

• The presence or absence of an aspiration contrast did not seem to strongly influence real-time processing

• Non-native English speakers more unsure over the course of a trial

• Overall having aspiration as a native contrast did not affect processing as much as predicted

• Future directions:
  • Run more native French speakers
  • A follow up study that would manipulate /s/ duration and VOT duration to determine which cues are being used during processing
Selected References


