ACOUSTIC MEMORY IN L2 VOWEL PERCEPTION

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Factors affecting L2 perception/production

- **Age of L2 learning** (Long, 1990; Flege *et al.*, 1995, 1999)
- **L1 influence** (Best, 1995; Flege, 1995)
- **Quality and quantity of input** (Flege, 2009; Moyer, 2009)
- **Amount of L1/L2 use** (MacKay *et al.*, 2001; Piske *et al.*, 2001)

Cannot explain remaining inter-subject variation in L2 phonological development
Factors affecting L2 perception/production

Individual differences in cognitive ability:

- musical aptitude (Gottfried, 2007; Slevk & Miyake, 2006)
- phonetic talent (Jilka et al., 2007)
- phonological short-term memory (Cerviño-Povedano & Mora, 2011; MacKay et al., 2001)
- aptitude for oral mimicry (Purcell & Suter, 1980)

Little is known: relationship between these factors and L2 perception/production
Why explore?!

- Remain underresearched
- Examining relationship between cognitive abilities and L2 phonological acquisition
  - May help to identify characteristics of learners
    - who struggle with L2 phonological acquisition
    - who successfully master L2 pronunciation
The Present Study: Focus

- Inter-subject variation in L2 target-like perception
  (weighting of phonetic cues in speech perception)

Best, 1995; Bohn, 1995; Cerviño-Povedano & Mora, 2009;
Escudero & Boersma, 2004; Flege, 1991; Mora & Fullana, 2007
Problems with L2 perception

1. Cross-linguistic phonetic similarity affects:
   • L2 perception through L1 - inaccurate formation of L2 categories

   Why?
   • L1 phonetic prototypes - “magnets”
   • Perceptual assimilation to the most similar L1 phoneme

2. Cue-weighting:
   • Reliance on wrong cue

   Why?
   • More salient (E.g. Duration)

What to do?
• Discern phonetic differences between L1 and L2
• Rely on right phonetic cue

Best, 1995; Bohn, 1995; Kuhl, 1994; Flege, 1995
The Present Study: Focus

- Inter-subject variability in L2 target-like perception (weighting of phonetic cues in speech perception)
- Spanish/Catalan EFL learners difficulty in target-like perception of English /i:/ and /ɪ/ contrast
  - Single Category assimilation
    English /i:/ - /ɪ/ to the Native /i/ category
  - Overreliance on duration when perceiving /i:/ and /ɪ/ contrast
- Individual differences in Acoustic Memory (AM)

Best, 1995; Bohn, 1995; Cerviño-Povedano & Mora, 2009; Escudero & Boersma, 2004; Flege, 1991; Mora & Fullana, 2007
Acoustic Memory (AM)

Listeners must process acoustic phonetic features before speech becomes intelligible (can be understood and repeated):

- Voicing
- Duration
- Pitch

Acoustic Memory is the storage capacity for the auditory processing of acoustic phonetic features kept at a pre-lexical level, i.e. prior to phonological encoding (before intelligibility occurs).
### Acoustic Memory (AM)

<table>
<thead>
<tr>
<th>Phonological memory</th>
<th>Acoustic memory</th>
</tr>
</thead>
<tbody>
<tr>
<td>operates at the phonological level</td>
<td>acoustic/phonetic details of the speech signal (pitch, voicing, duration)</td>
</tr>
<tr>
<td>handles phonological units</td>
<td>within-category vowel discrimination</td>
</tr>
<tr>
<td>between-category discrimination</td>
<td>L2-L1 sound mapping</td>
</tr>
</tbody>
</table>

- Spanish/Catalan EFL: /i/-/ɪ/ - within-category discrimination

**ASSUMPTION:** Individuals with greater AM capacity more sensitive to differences in acoustic information between perceptually similar L2 vowels and perceptually close L2-L1 vowel pairs.

Baddeley, 2003; Isaacs & Trofimovich, 2011; Darwin & Baddeley, 1974; Pisoni, 1973; Cowan & Morse, 1986
Acoustic Memory (AM)

How can we measure AM? (general auditory processing)

Stimuli should:
- be non-intelligible
- avoid phonological encoding
- be as acoustically complex as speech

Rotated Speech (through spectral inversion)

- non-intelligible (would require specific training)
- as temporally and spectrally complex as speech
- preserves most speech-like properties in the spectral and temporal domains
  (voicing, friction, pitch changes)

(Blomert, 1995; Spetz et al., 2000)
The Present Study: Aim and RQ

AIM:
- To investigate the extent to which Acoustic Memory is related to L2 vowel perception.

RQ:
- Are L2 learners with higher acoustic memory capacity better able to rely on spectral information than lower ability learners in the perception of the English tense-lax /i:/-/ɪ/ contrast?

Hypothesis

Individuals with higher acoustic memory capacity might be better able to rely on spectral information in the discrimination of English /i:/ and /ɪ/ because they would be more sensitive to the qualitative differences underlying this vowel contrast.
The Present study: Method

- Participants:
  - 53 Spanish/Catalan EFL learners (mean age: 20.9)
  - 13 NS – baseline data
  - No speech disorders or hearing problems
  - Self-estimated proficiency level: from intermediate to advanced

- Tasks and Procedure:
  - Linguistic Background Questionnaire
  - Acoustic memory (Serial Nonword Recognition task)
  - Cue-weighting in L2 vowel perception (Vowel Discrimination Task)
The Present Study: Materials

- Acoustic memory task:
  - SNWR task adapted:
    Same or different

Spectrally Rotated Speech

- temporal and spectral complexity of ordinary speech, but NOT intelligible
- cannot be phonologically encoded, understood, repeated or sub-vocally rehearsed (Scott et al., 2000)
- subjects are forced to rely only on the acoustic information
The Present Study: Materials

[man]

Rotated [man]
The Present Study: Materials

- **Stimuli**
- Catalan nonwords (144 nonwords) spectrally rotated using Praat
- 3-, 4-, 5- and 6-item length sequence pairs
- 32 testing trials and 2 initial warm-up trials

<table>
<thead>
<tr>
<th>Sequence</th>
<th>SAME</th>
<th>DIFFERENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-item length</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>4-item length</td>
<td></td>
<td>✓ ✓</td>
</tr>
<tr>
<td>5-item length</td>
<td>✓ ✓</td>
<td></td>
</tr>
<tr>
<td>6-item length</td>
<td>✓ ✓</td>
<td></td>
</tr>
</tbody>
</table>

*Measure: weighted score (out of 144) (O’Brian et al., 2007)*
The Present Study: Materials

- Vowel Discrimination Task

FC AXB Categorical Discrimination Test (Moya-Galé & Mora, 2011)

- /i:/ and /ɪ/ in 6 CVC minimal pairs /b_d/, /d_d/, /s_d/, /b_t/, /p_k/, /p_t/
- 6 native English speakers (3 males, 3 females)
- 72 natural and 72 duration manipulated stimuli
- Different tokens within trial
- Different speakers within trial

bead – bid – bid
(male¹ - female³ - male²)
Results: AXB discrimination

- **Non-Native**
  - NAT: $M = 83.34$
  - MAN: $M = 74.19$
  - $t(52) = 7.14, p < .001$

- **Native**
  - NAT: $M = 97.50$
  - MAN: $M = 96.35$
  - $t(12) = 1.39, p = .190$
Results: Correlations

<table>
<thead>
<tr>
<th></th>
<th>AM</th>
<th>DIS (NAT)</th>
<th>DIS (MAN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM</td>
<td></td>
<td>0.499**</td>
<td>0.441**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.291*</td>
<td>0.299*</td>
</tr>
<tr>
<td>DIS (NAT)</td>
<td></td>
<td></td>
<td>0.758**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.716**</td>
</tr>
</tbody>
</table>

** Correlation is significant at .001 level
* Correlation is significant at .05 level (control for proficiency)
Results: Acoustic Memory

![Graph showing the decline in acoustic memory with increasing item length. The graph indicates a decrease from 100 to 55 with the transition from 3-item length to 6-item length. The 5-item length shows a notable plateau.]
Results: Acoustic Memory

ANOVA within: Nat/Man 
$p<.001$

ANOVA between: Low/High 
$p<.05$

Group differences:
Low AM ($N=23$) 
High AM ($N=30$) 
Nat: $p=.008$
Man: $p=.030$
Results: Regression

- $R^2 = 0.343$ (34%); $p = 0.002$ (DIS)
- $R^2 = 0.330$ (33%); $p = 0.003$ (NAT)
- $R^2 = 0.283$ (28%); $p = 0.01$ (MAN)

### Table: Acoustic Memory

<table>
<thead>
<tr>
<th></th>
<th>% Unique variance explained</th>
<th>$p =$</th>
<th>AXB Discrimination</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acoustic Memory</strong></td>
<td>19.7%</td>
<td>0.001</td>
<td>NAT</td>
</tr>
<tr>
<td></td>
<td>13.3%</td>
<td>0.007</td>
<td>MAN</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>18.4%</strong></td>
</tr>
</tbody>
</table>
Discussion and Conclusions

THE PRESENT STUDY

Acoustic Memory:

✓ IS RELATED to L2 vowel perception
✓ L2 learners with higher acoustic memory are better able to rely on spectral information than lower ability learners in the perception of the English tense-lax /iː/-/ɪ/ contrast

THUS it may:

• facilitate target-like cue-weighting
• explain inter-learner variation in L2 phonological attainment
• provide learners with an advantage in phonetic training involving backrounding and foregrounding of L2-specific acoustic features
Discussion and Conclusions

Methodological issues to be solved:

- improve the task
- control saliency of consonants
- control difficulty of the items (sequence length, ISI)
- validate the task
Discussion and Conclusions

ONGOING RESEARCH: Task Validation

- **Original Task (3-6 item length):**
  - Catalan CVC
  - 3-6 item length
  - ISI 200ms and 750ms
  - Cronbach’s alpha = 0.160

- **Version 2:**
  - Catalan CVC
  - 4-6 item length
  - ISI 150ms and 1000ms
  - Cronbach’s alpha = 0.375

- **Version 3:**
  - Catalan VCV nonwords
  - 3-5 item length
  - ISI 150ms and 1000ms
  - Cronbach’s alpha = 0.632
Discussion and Conclusions

<table>
<thead>
<tr>
<th>Item length</th>
<th>Same</th>
<th>Different</th>
<th>Cronbach’s alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-item length</td>
<td>❉</td>
<td>❉</td>
<td>0.424</td>
</tr>
<tr>
<td>4-item length</td>
<td>❉</td>
<td>❉</td>
<td>0.470</td>
</tr>
<tr>
<td>5-item length</td>
<td>❉</td>
<td>❉</td>
<td>0.189</td>
</tr>
</tbody>
</table>
Discussion and Conclusions

FUTURE RESEARCH:

• Solve methodological issues
• Improve and Validate the task (stimuli need revision)
• Reliable proficiency measure
• Other cognitive abilities: E.g. ability for oral mimicry
• Focus on both: L2 speech perception and production
Thank you!

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