Phonological Attention Control, Inhibition, and Second Language Speech Learning

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Factors affecting L2 phonological acquisition

Learning conditions:
- L1 background (e.g. Flege, Bohn, & Jang, 1997)
- Age and length of L2 exposure (e.g. Flege, Yeni-Komshian, & Liu, 1999; Johnson & Newport, 1989)
- Frequency or amount of L1/L2 use (e.g. Guion et al., 2000)

→ when controlled, individual differences remain in L2 phonological development (e.g. Pallier et al., 1997)

Cognitive abilities:
- Working memory (e.g. Papagno & Vallar, 1995; MacKay, Meador, & Flege, 2001; Cerviño-Povedano & Mora, 2011; Service, 1992; Masoura & Gathercole, 1999)
- Attention control (Guion & Pedersen, 2007; Segalowitz & Frenkiel-Fishman, 1997)
- Inhibition (Lev-Ari & Peperkamp 2012)
- Lexical retrieval (Segalowitz, 1997) and vocabulary size (Bundgaard-Nielsen, Best, & Tyler, 2011)

→ Not well known: how these factors relate to L2 phonological development in perception and production
Possible candidates

• **Phonological attention control (AC)**
  – the ability to flexibly and efficiently shift attention between linguistic dimensions (*Segalowitz & Frenknel-Fishman, 2005*)
  – For L2 phonology: more efficient AC may enhance the processing of acoustic-phonetic information in the input and lead to higher performance in L2 speech perception/production (*Safronova & Mora, 2012; Mora & Gilabert, 2012*)

• **Inhibition skill**
  – Stronger inhibitory skill might result in better inhibition of the first language when using the L2, and to more efficient phonological processing when switching between languages (*Lev-Ari & Peperkamp, 2012*)
In addition

• Vocabulary size
  – Good measure of overall proficiency
  – A larger vocabulary facilitates phonological inference in L1 acquisition (Munson et al., 2005)
  – In L2, it may also be related to phonological competence (vowel perception: Bundgaard-Nielsen, Best, & Tyler, 2011)

=> we use vocabulary size as a (phonologically related) measure of proficiency, and include it as a covariate in analyses
Our study

Spain
- 35 L2 learners of English
- 10 Sp. native speakers
  - Universidad de Sevilla (Spain)

United States
- 26 L2 learners of Spanish
- 10 Eng. native speakers
  - Indiana University (Bloomington, USA)

- Attention Control
- Inhibition

- L2 production
- L2 perception

- Pure tone hearing test
- Vocabulary size
- Background questionnaire

L2 production
L2 perception
L2 phonological processing: group data

- Production
- Perception
Production

- Delayed Sentence Repetition task
- 4 pairs of sentences for each contrast (total: 16 per language)
- Learners produced L2 sentences
- Native speakers produced the control measures in L1

**Spanish L2**

/e/ - /eI/
- ¿Qué ruido ha sido ese? Es la maceta que se ha roto.
- ¿Qué le pones a la ensalada? Un buen aceite de oliva.

/r/ - /d/
- ¡Parece que tienes frío! Tengo la cara helada del frío.
- ¿No nos ha contado esta historia antes? Cuenta cada historia mil veces.

**English L2**

/i:/ - /I/
- Which one do you like best? I like the cheap one.
- What would you like with it? I’ll have the chips please.

/ʃ/ - /tʃ/
- Could you buy some wine? All the shops are closed, sorry.
- Are you not finishing the pork chops? The chops are too much, I’m full.
## Production

- **Delayed Sentence Repetition task**
- **4 pairs of sentences for each contrast (total: 16 per language)**
- **Learners produced L2 sentences**
- **Native speakers produced the control measures in L1**

<table>
<thead>
<tr>
<th>Spanish L2</th>
<th>English L2</th>
</tr>
</thead>
<tbody>
<tr>
<td>/e/ - /eɪ/</td>
<td></td>
</tr>
<tr>
<td>• 3 measurement points (MP) within vowels: F1, F2, F0</td>
<td></td>
</tr>
<tr>
<td>• Amount of tongue movement (Bark difference score) from MP2 to MP1</td>
<td></td>
</tr>
<tr>
<td>• /ɾ/ - /d/</td>
<td></td>
</tr>
<tr>
<td>• Visual and auditory examination of spectrogram</td>
<td></td>
</tr>
<tr>
<td>• Categorical decision about tap vs. spirantized [ð]</td>
<td></td>
</tr>
<tr>
<td>• Score out of 8</td>
<td></td>
</tr>
<tr>
<td>/iː/ - /ɪ/</td>
<td></td>
</tr>
<tr>
<td>• 3 measurement points (MP) within vowels: F1, F2, F0</td>
<td></td>
</tr>
<tr>
<td>• Spectral distances (Bark) at midpoint and Euclidean distances</td>
<td></td>
</tr>
<tr>
<td>• /ʃ/ - /tʃ/</td>
<td></td>
</tr>
<tr>
<td>• Visual and auditory examination of spectrogram</td>
<td></td>
</tr>
<tr>
<td>• Categorical decision about presence vs. absence of closure</td>
<td></td>
</tr>
<tr>
<td>• Score out of 8</td>
<td></td>
</tr>
</tbody>
</table>
Production: results

**Spanish L2**
/e/-/eɪ/: amount of tongue movement

**English L2**
/i:/ - /ɪ/: spectral differences (Bark)

<table>
<thead>
<tr>
<th>/r/ - /d/: Average score (max. 8)</th>
<th>L2 learners</th>
<th>Mean score</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = 26</td>
<td>4.27</td>
<td>2.20</td>
<td></td>
</tr>
<tr>
<td>Native speakers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Spanish)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n = 9</td>
<td>7.89</td>
<td>0.3</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>/ʃ/-/tʃ/: Average score (max. 8)</th>
<th>L2 learners</th>
<th>Mean score</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = 35</td>
<td>6.89</td>
<td>1.32</td>
<td></td>
</tr>
<tr>
<td>Native speakers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(English)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n = 10</td>
<td>8</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
Perception

**Speeded categorial ABX task**

<table>
<thead>
<tr>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>time</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>A</td>
<td>A or B</td>
</tr>
<tr>
<td>A</td>
<td>B</td>
<td>B</td>
<td></td>
</tr>
</tbody>
</table>

**Response:**

female voice 1  \[
\]  female voice 2

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**Stimuli recorded by two native bilingual speakers (Sp./Am.Eng.)**

**All subjects heard the same stimuli**

**Language switch between 2 blocks**

**4 items per condition**

**ABA, ABB, BAA, BAB = 128 trials**

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**Trisyllabic nonword stimuli**

<table>
<thead>
<tr>
<th>Stimulus language</th>
<th>item A</th>
<th>item B</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spanish</td>
<td>saˈɾeβo</td>
<td>saˈdεβo</td>
<td>Test C</td>
</tr>
<tr>
<td>English</td>
<td>saˈʃiːdən</td>
<td>saˈtʃiːdən</td>
<td>Test C</td>
</tr>
<tr>
<td>Spanish</td>
<td>faˈneða</td>
<td>faˈneiða</td>
<td>Test V</td>
</tr>
<tr>
<td>English</td>
<td>faˈniːdɪʃ</td>
<td>faˈnɪdɪʃ</td>
<td>Test V</td>
</tr>
<tr>
<td>Spanish</td>
<td>gaˈtaso</td>
<td>gaˈðaso</td>
<td>Control C</td>
</tr>
<tr>
<td>English</td>
<td>gaˈtæfɪn</td>
<td>gaˈdæfɪn</td>
<td>Control C</td>
</tr>
<tr>
<td>Spanish</td>
<td>luˈpito</td>
<td>luˈpato</td>
<td>Control V</td>
</tr>
<tr>
<td>English</td>
<td>ləˈpiːdɪk</td>
<td>ləˈpædɪk</td>
<td>Control V</td>
</tr>
</tbody>
</table>
Cognitive and proficiency measures

- Attention Control
- Inhibition
- Vocabulary size
Attention Control

- New task
- Auditory analog of the Dimensional Change Card Sort Task (Bialystok & Martin 2004)
- Switch-Repeat Alternation (Segalowitz & Frenkiel-Fishman, 2005)

Participants must switch attention between acoustic dimensions: **Nasality** vs. **Native language**

These two dimensions can be used for both groups equally

Two native bilinguals (Sp./Am.Eng) recorded both sets of stimuli

<table>
<thead>
<tr>
<th>Spanish Nasal</th>
<th>English Nasal</th>
</tr>
</thead>
<tbody>
<tr>
<td>'noma</td>
<td>'noʊmə</td>
</tr>
<tr>
<td>'nole</td>
<td>'noʊleɪ</td>
</tr>
<tr>
<td>'niso</td>
<td>'nɪsoʊ</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spanish Nonnasal</th>
<th>English Nonnasal</th>
</tr>
</thead>
<tbody>
<tr>
<td>'piɣo</td>
<td>'pɪɣoʊ</td>
</tr>
<tr>
<td>'dofe</td>
<td>'dɔfəi</td>
</tr>
<tr>
<td>'saso</td>
<td>'sæsəʊ</td>
</tr>
</tbody>
</table>
**Attention Control: results**

<table>
<thead>
<tr>
<th>Question</th>
<th>Auditory stimulus</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>English?</td>
<td>['doʊfeɪ]</td>
<td>YES</td>
</tr>
<tr>
<td>English?</td>
<td>['noma]</td>
<td>NO</td>
</tr>
<tr>
<td>Nasal?</td>
<td>['sæsoʊ]</td>
<td>NO</td>
</tr>
<tr>
<td>Nasal?</td>
<td>['niso]</td>
<td>YES</td>
</tr>
</tbody>
</table>

**Measure:**
RT on **Switch** vs. **Repeat** (baseline) conditions

**Shift cost:** **Switch** – **Repeat**, for each individual

![Bar graph showing RT differences between Switch and Repeat conditions for English and Spanish L1s.](chart.png)

*Error bars: +/- 1 SE*
Inhibitory skill task

- Task conducted in L1 only (Spanish or English)

Inhibitory skill task

**Memorize**
- Vegetables
  - Lettuce
  - Potato
  - Artichoke
  - Onion
  - Spinach
  - Tomato
- Animals
  - Duck
  - Snake
  - Elephant
  - Horse
  - Tiger
  - Cow
- Occupations
  - Plumber
  - Teacher
  - Fireman
  - Carpenter
  - Engineer
  - Nurse

**Practice**
- Vegetables
  - Lettuce
  - Potato
  - Artichoke
  - Onion
  - Spinach
  - Tomato
- Animals
  - Duck
  - Snake
  - Elephant
  - Horse
  - Tiger
  - Cow
- Occupations
  - Plumber
  - Teacher
  - Fireman
  - Carpenter
  - Engineer
  - Nurse

**Inhibited**

**Recognize**
- Vegetables
  - Lettuce
  - Potato
  - Artichoke
  - Onion
  - Spinach
  - Tomato
- Animals
  - Duck
  - Snake
  - Elephant
  - Horse
  - Tiger
  - Cow
- Occupations
  - Plumber
  - Teacher
  - Fireman
  - Carpenter
  - Engineer
  - Nurse

PLUS distractor items never presented before (e.g. secretary)

**Inhibition score** = \( \frac{(RT \ to \ inhibited)}{(RT \ to \ control)} \)
Inhibition: results

![Inhibition and Reaction Time Graphs](image)

**Non-learners**
- Reaction Time (ms): [600, 1100]
- Inhibition Score: [0.00, 1.80]

**L2 Spanish**
- Reaction Time (ms): [600, 1100]
- Inhibition Score: [0.00, 1.80]

**L2 English**
- Reaction Time (ms): [600, 1100]
- Inhibition Score: [0.00, 1.80]
### Vocabulary size (receptive)

<table>
<thead>
<tr>
<th>X-Lex/Y-Lex Test (Meara &amp; Miralpeix, 2006)</th>
<th>Peabody Picture Vocabulary Test (PPVT, Dunn &amp; Dunn, 2007)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• For L2 learners</td>
<td>• For native speakers, children and adults</td>
</tr>
<tr>
<td>• See a printed word and decide if it is known or not</td>
<td>• Hear a spoken word and choose one out of four pictures</td>
</tr>
<tr>
<td>• Various frequency bands</td>
<td>• Items arranged from “easiest” to “hardest” (but: for native speakers)</td>
</tr>
<tr>
<td>• X-Lex = 5000 most frequent</td>
<td>• For L2 English: PPVT 4</td>
</tr>
<tr>
<td>• Y-Lex = 10,000 most freq.</td>
<td>– (British or American English versions)</td>
</tr>
<tr>
<td>• For L2 Spanish, only X-Lex available</td>
<td>• For L2 Spanish: PPVT 3</td>
</tr>
<tr>
<td></td>
<td>– (Peninsular or Latin Am. Spanish versions)</td>
</tr>
</tbody>
</table>
Vocabulary size (examples)

X-Lex/Y-Lex Test
(Meara & Miralpeix, 2006)

Peabody Picture Vocabulary Test
(PPVT, Dunn & Dunn, 2007)
Vocabulary size: rationale

• X-Lex / Y-lex is a great measure of vocabulary size, but for L2 Spanish, only X-lex available

• So we decided to use PPVT as well because both Spanish and English versions were available

• However: PPVT was developed for L1
  – Need to make sure that the PPVT scores (error rate) and X-lex/Y-lex scores are correlated, before using PPVT as valid vocabulary size measure for the two groups.

• Results: X-lex/Y-lex scores significantly correlate with PPVT for the Spanish L1 group (for whom we have that score): $r = -0.633, p < 0.01$
Correlations
Data

• Only participants with valid data in all tasks are selected for this analysis (82 → 40)
  – Audiometry (- n = 18)
  – Background questionnaire (- n = 15)
    • speech pathology, bilingual or fluent in another language using our test contrasts (e.g. Italian), not English or Spanish native speaker, use L2 too early …
  – Attention Control (- n = 3)
  – Inhibition (- n = 2)
  – ABX (- n = 4)

• Total of 40 participants: 16 L2-English + 18 L2-Spanish + 6 Native speakers
## L2 learners

<table>
<thead>
<tr>
<th>L2</th>
<th>N</th>
<th>Mean (SD)</th>
<th>t</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English</td>
<td>16</td>
<td>23.3 (5.38)</td>
<td>2.77</td>
<td>15.4</td>
<td>.014</td>
</tr>
<tr>
<td>Spanish</td>
<td>18</td>
<td>19.6 (0.70)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Motivation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English</td>
<td>16</td>
<td>6.0 (0.71)</td>
<td>2.11</td>
<td>23.3</td>
<td>.046</td>
</tr>
<tr>
<td>Spanish</td>
<td>18</td>
<td>5.6 (0.41)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Current L2 use</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English</td>
<td>16</td>
<td>17.4 (5.93)</td>
<td>3.7</td>
<td>32</td>
<td>.001</td>
</tr>
<tr>
<td>Spanish</td>
<td>18</td>
<td>9.1 (7.06)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Self-evaluation (1-5)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English</td>
<td>16</td>
<td>4.0 (0.37)</td>
<td>.67</td>
<td>28.9</td>
<td>.506</td>
</tr>
<tr>
<td>Spanish</td>
<td>18</td>
<td>3.9 (0.58)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LoR abroad (weeks)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English</td>
<td>16</td>
<td>5.4 (10.1)</td>
<td>-1.15</td>
<td>26.2</td>
<td>.259</td>
</tr>
<tr>
<td>Spanish</td>
<td>18</td>
<td>5.9 (15.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Years of study</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English</td>
<td>16</td>
<td>11.9 (2.77)</td>
<td>3.21</td>
<td>32</td>
<td>.003</td>
</tr>
<tr>
<td>Spanish</td>
<td>18</td>
<td>8.8 (2.94)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>First Exposure (age)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English</td>
<td>16</td>
<td>7.6 (2.13)</td>
<td>4.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spanish</td>
<td>18</td>
<td>8.8 (-1.15)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>First Use (age)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English</td>
<td>16</td>
<td>13.5 (4.40)</td>
<td>2.29</td>
<td>32</td>
<td>.029</td>
</tr>
<tr>
<td>Spanish</td>
<td>18</td>
<td>10.2 (3.96)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Compared to the learners in Seville (L2 English), learners in Bloomington (L2 Spanish) are younger, less motivated, speak the L2 less, have studied for less time, and started using Spanish earlier.
Our findings

PPVT error rate used as covariate to partial out proficiency

- Shift Cost (Attention)
- Inhibition

- Phonetic score (consonants vs. vowels)
- ABX accuracy

- Audiometry
- Vocabulary size
- Background variables

Spain
- 16 L2 learners of English
  - Universidad de Sevilla (Spain)

United States
- 18 L2 learners of Spanish
  - Indiana University (Bloomington, USA)
Our findings

L2 Spanish (r = .124) n.s.
L2 English (r = -.438)

- **Shift Cost** (Attention)
- **Inhibition**
- **Phonetic score** (consonants vs. vowels)
- **ABX accuracy**

- **Audiometry**
- **Vocabulary size**
- **Background variables**

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Our findings

- Shift Cost (Attention)
- Inhibition

- Phonetic score (consonants vs. vowels)
- ABX accuracy

Spain
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L2 Spanish (n.s.)
L2 English (r = -.366)

L2 Spanish (n.s.)
L2 English (r = .640)

L2 Spanish (n.s.)
L2 English (r = .640)

Audiometry
- Vocabulary size
- Background variables
Take-home message

• Inhibition and attention control are associated with L2 processing of consonants and vowels, when proficiency is partialed out

• Perception
  – Learners with higher inhibitory skill are perhaps able to deactivate (or inhibit) the language not in use more efficiently, and this might help them obtain higher accuracy scores in our categorial ABX task
  – Attention control is also associated with more accurate performance in ABX (for the L2 English learners), but less strongly than inhibition

• Production
  – Inhibition is not related to production scores
  – Attention control is related to consonant production for L2 English learners

• Next step will examine whether such an advantage in speech processing is the result of more efficient executive function

• A stronger Inhibition and more efficient Attention control might be facilitating phonological learning
Thank you!

- Shiri Lev Ari, Sharon Peperkamp (LSCP, Paris)
- Paola Rodrigues, Tanya Flores, Diana Arroyo, Ana Fernandez, Maggie Peters, Fiona Pannatt
- Amanda Rabideau (Univ. of Utah)
- Elena Safronova (Barcelona)
- Eva Cerviño-Povedano (Barcelona)
- Marina Barrio Parra, M. Heliodora Cuenca Villarín (Sevilla)
- Ron Roosevelt (Sevilla)

- Carmen Muñoz (Barcelona)
- Kathleen Bardovi-Harlig (Bloomington)
- SLPL lab members (Bloomington)
- Jeffrey Holliday (Bloomington)
- Grant support:
  - Grant-in-Aid, Indiana University Bloomington
  - Grants HUM2007-64302 (Ministerio de Ciencia e Innovación) and 2009SGR137 (Generalitat de Catalunya)

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References


References


