Inhibition and Phonological Processing in a Second Language

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Introduction: L2 phonological acquisition is influenced...

**Contextual factors:**
- L1 background
- L2 exposure (AOL, LoR)
- Frequency and amount of L1/L2 use

(e.g. Flege, Bohn, & Jang, 1997, Flege, Yeni-Komshian, & Liu, 1999; Guion et al., 2000)

- **L2 vocabulary size** (Bundgaard-Nielsen, Best & Tyler, 2011)

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

**Cognitive factors:**
- Working memory (phonological short-term memory), attention control, speed of lexical retrieval, inhibition

(Cerviño-Povedano & Mora, 2011; Guion & Pederson, 2007; Lev-Ari & Peperkamp, 2012; MacKay, Meador & Flege, 2001; Masoura & Gathercole, 1999; Papagno & Vallar, 1995; Safronova & Mora, 2013; Segalowitz 1997; Service 1992)

⇒ no study relates cognitive factors to both perception and production of Vs and Cs; Inhibition under-researched for L2 phonology
Inhibitory skill
A person’s ability to bring to the background stimuli types (visual, auditory) or stimuli features (colour, shape) that are irrelevant to the mental process at hand. (Miyake et al. 2000)
- few studies relating Inhibition to L2 phonological development

→ Stronger inhibitory skill might result in better inhibition of the language not in use, and in more efficient phonological processing when switching between speech dimensions or languages.
→ Greater inhibitory capacity may lead to more successful suppression of L1 interference in L2 phonological processing.
→ more accurate L2 speech perception/production.
  (Costa & Santesteban, 2004; Costa, Santesteban & Ivanova, 2006)
Introduction: Attention control and PSTM

**Phonological attention control (AC):**
A person’s ability to shift focus of attention from one speech dimension (e.g.: *duration*) to another (e.g. *voice quality*)

- more efficient AC may enhance the processing of acoustic-phonetic information in the input and lead to more accurate L2 speech perception/production

**Phonological short-term memory (PSTM):**
Holds phonological elements and their serial order in memory for a few seconds before decay (refreshed through sub-vocal rehearsal).

- larger PSTM capacity may facilitate discrimination of L1-L2 phonetic differences, leading to the development of more accurate representations for L2 categories.
The present study

**Inhibition**
- Attention control
- PSTM

**L2 production**

**L2 perception**

- Pure tone hearing test
- Vocabulary size
- Background questionnaire

**Spain**
- 35 L2 learners of English (L1 Spanish Monolinguals)
  + 10 native speakers (control)
  Universidad de Sevilla

- 52 L2 learners of English (Spanish-Catalan Bilinguals)
  Universitat de Barcelona

**United States**
- 26 L2 learners of Spanish (L1 English Monolinguals)
  + 9 native speakers (control)
  Indiana University
The present study

Spain

52 L2 learners of English (Spanish-Catalan Bilinguals) Universitat de Barcelona

- Could understand & speak both Ls
- Used Spanish & Catalan daily
- Differed in amount of use of less dominant language.

2 groups:
- < 30% “unbalanced”
- > 30% “balanced”

Unbalanced bilinguals need to strongly inhibit their more proficient language when using their less dominant one (≠ “balanced” bilinguals).

> enhanced inhibitory skill
> more efficient L1 inhibition when using L2 English
L2 phonological processing

L2 production
- Delayed sentence repetition task
  Vowel production
  Consonant production

L2 perception
- ABX Categorization
  Vowel contrasts
  Consonant contrasts
**Production task**

- 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

<table>
<thead>
<tr>
<th>/el/ - /eI/</th>
<th>/l/ - /ðl/</th>
</tr>
</thead>
<tbody>
<tr>
<td>¿Qué ruido ha sido ese? Es la <strong>maceta</strong> que se ha roto.</td>
<td>Parece que tienes frío! Tengo la <strong>cara</strong> helada del frío.</td>
</tr>
<tr>
<td>¿Qué le pones a la ensalada? Un buen <strong>aceite</strong> de oliva.</td>
<td>No nos ha contado esta historia antes? Cuenta <strong>cada</strong> historia mil veces.</td>
</tr>
</tbody>
</table>

### English L2

<table>
<thead>
<tr>
<th>/iː/ - /ɪ/</th>
<th>/ʃ/ - /tʃ/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which one do you like best? I like the <strong>cheap</strong> one.</td>
<td>Could you buy some wine? All the <strong>shops</strong> are closed, sorry.</td>
</tr>
<tr>
<td>What would you like with it? I’ll have the <strong>chips</strong> please.</td>
<td>Are you not finishing the pork <strong>chops</strong>? The <strong>chops</strong> are too much, I’m full.</td>
</tr>
</tbody>
</table>
Production measures

- 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/ - /e/ɪ /
- 3 measurement points (MP) within vowels: F1, F2, F3, F0
- Amount of tongue movement (Bark difference score) from MP2 to MP1

/ɾ/ - /ð/
- Visual and auditory examination of spectrogram
- Categorical decision about tap vs. spirantized /ð/
- Score out of 8

**English L2**
/i:/ - /ɪ/
- 3 measurement points (MP) within vowels: F1, F2, F3, F0
- Spectral distances (Bark) at midpoint and Euclidean distances

/ʃ/ - /tʃ/
- Visual and auditory examination of spectrogram
- Categorical decision about presence vs. absence of closure
- Score out of 8
Production measures

- 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/ - /eɪ /
- 3 measurement points (MP) within vowels: F1, F2, F3, F0
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- 3 measurement points (MP) within vowels: F1, F2, F3, F0
- Spectral distances (Bark) at midpoint and Euclidean distances
- Visual and auditory examination of spectrogram
- Categorical decision about tap vs. spirantized /ð/
Production results

**L2 Spanish**

/e/-/eɪ/: amount of tongue movement

<table>
<thead>
<tr>
<th></th>
<th>Amount of tongue movement (difference in Bark)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monophthong</td>
<td>L2 Learners</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Diphthong</td>
<td></td>
</tr>
</tbody>
</table>

**L2 English**

/i/: /I/: spectral differences (Bark)

<table>
<thead>
<tr>
<th></th>
<th>Mean score</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2 learners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>n = 26</td>
<td>4.27</td>
<td>2.20</td>
</tr>
<tr>
<td>Native speakers (Spanish)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>n = 9</td>
<td>7.89</td>
<td>0.3</td>
</tr>
</tbody>
</table>

(consonants not presented)
Perception task: speeded categorical ABX task

- Stimuli in Spanish and English (non-words)
- Stimuli recorded by two female early balanced bilinguals (Mexican Spanish / American English)
- All subjects heard all stimuli
- Language switch between 2 blocks
- 4 orderings: ABA, ABB, BAA, BAB = 128 trials
### Perception task: speeded categorical ABX task

Sample of trisyllabic nonword stimuli in Spanish and English
[4 items per condition]

<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>saˈðeβo</td>
<td>Test C</td>
</tr>
<tr>
<td>English</td>
<td>seˈʃiːdən</td>
<td>seˈtʃiːdən</td>
<td>Test C</td>
</tr>
<tr>
<td>Spanish</td>
<td>faˈneða</td>
<td>faˈneɪða</td>
<td>Test V</td>
</tr>
<tr>
<td>English</td>
<td>fəˈniːdɪʃ</td>
<td>fəˈnɪdɪʃ</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>gəˈtæfɪn</td>
<td>gəˈdæfɪn</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>
Perception results (test conditions)

- L2 Stimuli
- L1 Stimuli

- L2 Spanish (Bloomington)
- L2 English (Sevilla)
- L2 English (Barcelona)

Consonants
Vowels
Cognitive tasks

**Inhibition**
- Retrieval-induced inhibition task

**Attention control**
- Novel speech-based attention-switching task

**Phonological short-term memory (PSTM)**
- Serial non-word recognition in Danish (L0)
Inhibitory skill task (L1 only)

<table>
<thead>
<tr>
<th>Memorize</th>
<th>Practice</th>
<th>Recognize</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Lettuce</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Potato</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Artichoke</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Onion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Spinach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Tomato</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Duck</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Snake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Elephant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Horse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Tiger</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Cow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occupations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Plumber</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Teacher</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Fireman</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Carpenter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Engineer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Nurse</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Inhibited**
  - Vegetables
  - Lettuce
  - Potato
  - Artichoke
  - Onion
  - Spinach
  - Tomato
  - Animals
  - Duck
  - Snake
  - Elephant
  - Horse
  - Tiger
  - Cow

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

Inhibition score = \( \frac{RT \text{ on inhibited}}{RT \text{ on control}} \)

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

Inhibition: Group Results

Error bar = 1 SD
Inhibition: Individual Results

Means = 1.03  1.04  1.19  1.02

$p < 0.03$
Novel attention-switching task

- **Auditory** analog of the Dimensional Change Card Sort Task (Bialystok & Martin 2004)
- **Switch-Repeat** (non-switch) alternation of stimuli. (Segalowitz & Frenkiel-Fishman, 2005; Safronova, 2013)

- 2 stimuli sets (Spanish & Am. English)
- 2 native bilinguals recorded 2 stimuli sets.

- Participants had to switch attention between acoustic dimensions: Nasality vs. Native language phonetics
- Same dimensions for both groups

<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>'piɣoʊ</td>
</tr>
<tr>
<td>'dofe</td>
<td>'dɔfəɪ</td>
</tr>
<tr>
<td>'saso</td>
<td>'sæsoʊ</td>
</tr>
</tbody>
</table>
### Novel attention-switching task

Example: L1 English learner of L2 Spanish

<table>
<thead>
<tr>
<th>Question</th>
<th>Auditory stimulus</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>English?</td>
<td>['dʌvfeɪ]</td>
<td>YES</td>
</tr>
<tr>
<td>English?</td>
<td>['nɒma]</td>
<td>NO</td>
</tr>
<tr>
<td>Nasal?</td>
<td>['sæsoʊ]</td>
<td>NO</td>
</tr>
<tr>
<td>Nasal?</td>
<td>['niːso]</td>
<td>YES</td>
</tr>
</tbody>
</table>

**Measures:**

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

**Shift cost:** **Switch** – **Repeat**, for each individual
Speech-based attention-shifting task

- Condition: Switch, Repeat

**Barcelona**

**Sevilla**

L2: Spanish

English (Barcelona)

English (Sevilla)
**Phonological short-term memory (PSTM)**

**Serial nonword recognition (SNWR) in L0 (Danish)**
Identifying pairs of nonword sequences of increasing length (5-6-7) as Same/Different:

<table>
<thead>
<tr>
<th>Danish</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>tys</td>
<td>dam</td>
<td>rød</td>
<td>mild</td>
<td>fup</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>vul</td>
<td>bend</td>
<td>sids</td>
<td>pák</td>
<td>ryd</td>
<td>ham</td>
<td>jøb</td>
</tr>
</tbody>
</table>

* no data for L2 Spanish

Cerviño-Povedano & Mora (2011)
Serial nonword recognition (SNWR) in L0 (Danish)*
Identifying pairs of nonword sequences of increasing length (5-6-7) as Same/Different:

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>tys dam rød mild fup</td>
<td>tys dam mild rød fup</td>
</tr>
<tr>
<td>2</td>
<td>vul bend sids påk ryd ham jøb</td>
<td>vul sids bend påk ryd ham jøb</td>
</tr>
</tbody>
</table>

* no data for L2 Spanish

Cerviño-Povedano & Mora (2011)
CORRELATIONS

- Inhibition
- Attention Control
- PSTM

- L2 production
- L2 perception

Vocabulary test score
used as covariate to partial out proficiency
Peabody Picture Vocabulary Test (PPVT)
### Findings

- **Inhibition score**

<table>
<thead>
<tr>
<th></th>
<th>Perception (ABX)</th>
<th>Production (Cs)</th>
<th>Production (Vs)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>L2 Sp</strong></td>
<td>$r = .507^*$</td>
<td>$r = .324$</td>
<td>$r = -.216$</td>
</tr>
<tr>
<td><strong>L2 En (Sev)</strong></td>
<td>$r = .615^*$</td>
<td>$r = .169$</td>
<td>$r = .024$</td>
</tr>
<tr>
<td><strong>L2 En (Bcn)</strong></td>
<td>$r = .012$</td>
<td>n.A.</td>
<td>$r = -.062$</td>
</tr>
<tr>
<td><strong>L2 En (Bcn)</strong> balanced</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(&gt; 30%)</td>
<td>$r = .160$</td>
<td>n.A.</td>
<td>$r = -.327$</td>
</tr>
<tr>
<td>unbalanced (&lt; 30%)</td>
<td>$r = .047$</td>
<td>n.A.</td>
<td>$r = -.050$</td>
</tr>
</tbody>
</table>
## Findings

**Attention control (Shift cost)**

- Perception (ABX)
- Production accuracy

### Table: Correlation Coefficients

<table>
<thead>
<tr>
<th></th>
<th>Perception (ABX)</th>
<th>Production (Cs)</th>
<th>Production (Vs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2 Sp</td>
<td>$r = .124$</td>
<td>$r = -.003$</td>
<td>$r = -.257$</td>
</tr>
<tr>
<td>L2 En (Sev)</td>
<td>$r = -.438^*$</td>
<td>$r = -.366$</td>
<td>$r = .640^*$</td>
</tr>
<tr>
<td>L2 En (Bcn)</td>
<td>$r = .220$</td>
<td>n.A.</td>
<td>$r = .132$</td>
</tr>
</tbody>
</table>
## Findings

**PSTM (SNWR score)**

- Perception (ABX)
- Production accuracy

<table>
<thead>
<tr>
<th></th>
<th>Perception (ABX)</th>
<th>Production (Cs)</th>
<th>Production (Vs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2 Sp</td>
<td>n.A.</td>
<td>n.A.</td>
<td>n.A.</td>
</tr>
<tr>
<td>L2 En (Sev)</td>
<td>r = .341</td>
<td>r = .322</td>
<td>r = .392</td>
</tr>
<tr>
<td>L2 En (Bcn)</td>
<td>r = .383**</td>
<td>n.A.</td>
<td>r = .313*</td>
</tr>
</tbody>
</table>
Discussion and Conclusions

Inhibition, attention and PSTM all seem to be related to phonological processing:
- NOT for all tasks
- NOT for all groups

The relationship interacts with linguistic profile

Monolingual Context:
- Inhibition is related to L2 perception, but not L2 production.
- Attention control is related to L2 perception, but not L2 production (L2 English in Seville only)

Bilingual Context:
- PSTM is related to L2 perception and L2 production
**Discussion and Conclusions**

**Inhibition**

- Inhibitory skill contributes to greater accuracy in ABX in a monolingual but not in a bilingual context.

**Why did we fail to find a relationship between Inhibition and perception for Barcelona bilinguals?**

- ABX requires switching between two languages within the same task.

- Monolinguals may not be used to such switching, whereas bilinguals do it on an everyday basis.

- Perhaps the effects of individual differences in inhibitory skill are “washed out” in bilinguals due to the daily practice they receive in inhibiting one language over the other.
Thank you!

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